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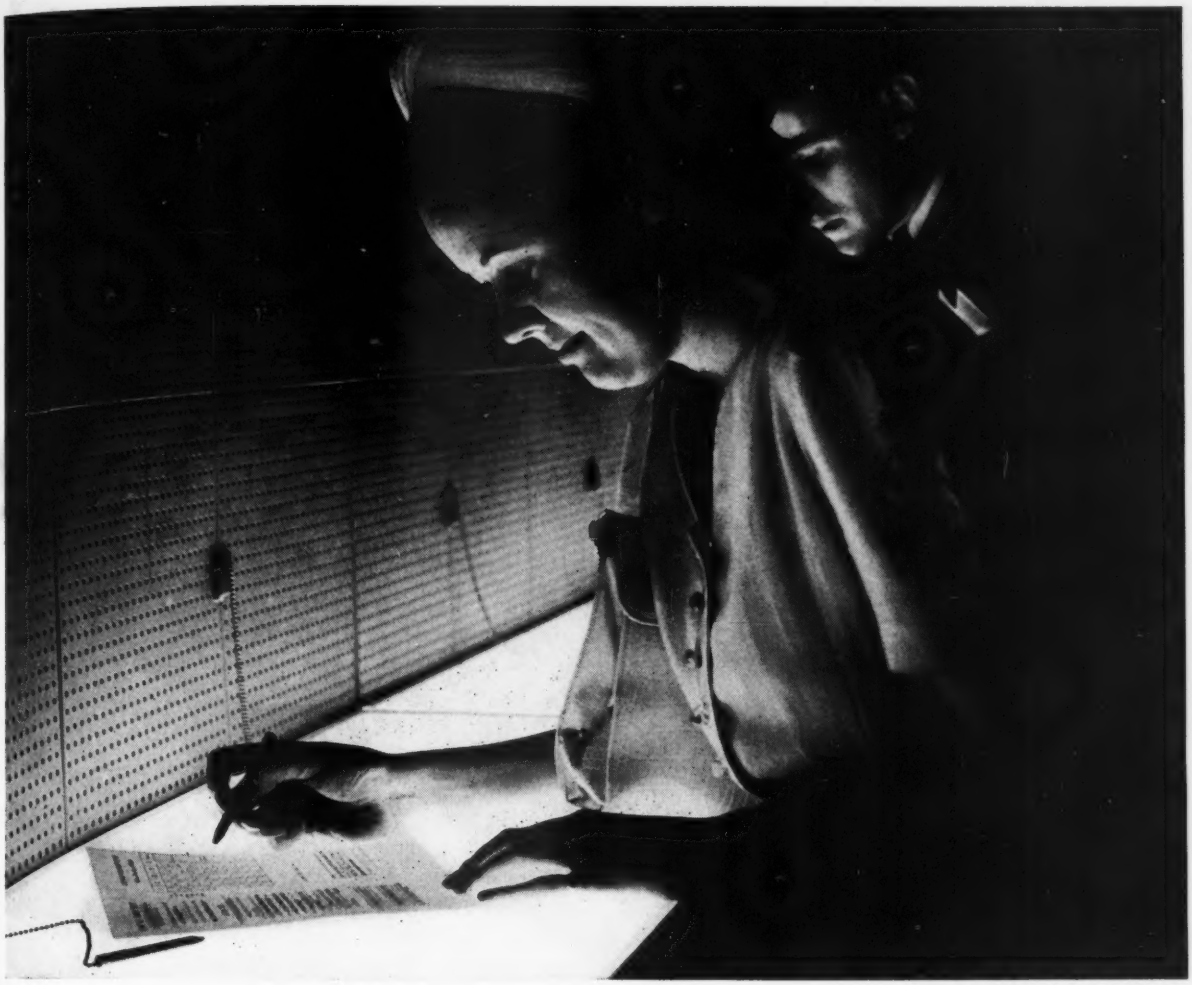


Photograph by John Mills, Jr.

A visitor checks her hearing-test card at the Telephone Exhibit, New York World's Fair

AUGUST 1939 VOLUME XVII NUMBER XII

Sorption of Water by Organic Insulating Materials

By R. L. TAYLOR
Chemical Laboratories

WHEN insulating materials like rubber and phenol plastics are immersed in water or exposed to humid air large changes may occur in their resistivity, dielectric constant, and power factor. These changes are caused by water which condenses on the surface, adsorbs in the interstices of the material, or is absorbed by soluble impurities. Laboratory studies of these effects help to predict the behavior of such materials in service.

Initially, the rate of sorption* is comparatively rapid whether the substance is immersed in water or water vapor; in most cases the amount of water taken up increases as the square root of the time of exposure. Characteristic sorption curves are shown in Figure 1 for soft vulcanized rubber and phenol plastic in distilled water.

*Sorption is used in conformity with current phraseology to signify the combined effect of adsorption and absorption.

The phenol plastic reaches a state of equilibrium where sorption ceases, but the rubber, which is elastic, may continue to take up water until it disintegrates and is dispersed throughout the liquid. This is illustrated by the logarithmic graphs of Figure 2. At vapor pressures less than saturation, equilibrium is reached by both phenol plastic and soft vulcanized rubber but the rate of sorption and final water content are less.

Several factors will cause sorption curves to deviate from straight lines before the point of equilibrium is reached. Among these are changes during the test in temperature or in relative vapor pressure. Leaching of water-soluble materials decreases the

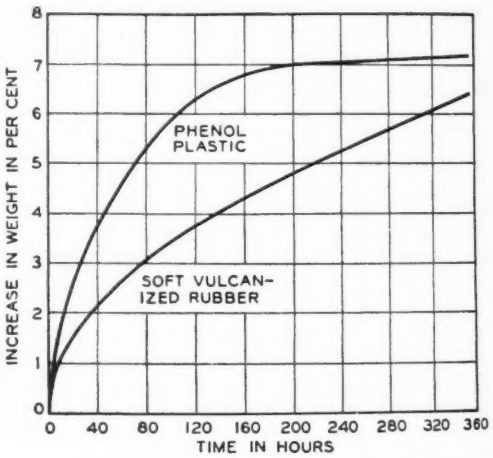


Fig. 1—Sorption of water by thin sheets of insulating materials that are immersed in distilled water

slopes of the curves; and the formation of additional water-soluble materials by oxidation shifts the curves upward. The latter is of particular significance because it is a measure of the deterioration of materials when they come in contact with water.

The straight-line logarithmic plot of Figure 2 can be used to predict the water content of materials exposed to water for a given length of time, if fixed conditions of temperature and relative vapor pressure are maintained. A rubber piece-part which, for example, sorbs 0.1 per cent water in one day will, in accordance with this straight-line relation, contain about six per cent water after ten years.

In the early stages of sorption the percentage increase in weight of sheet materials when exposed to water varies nearly inversely with the thickness of the sheet, provided its area is large in comparison with its thickness. Since the rate of sorption is given by the slope of a curve showing the increase in weight plotted against the square root of time, the slope for a sample of unit thickness will serve as a sorption coefficient to compare different materials. At room temperature the sorption coefficient for a phenol plastic is about 0.026; for soft rubber, 0.015 and for ebonite, 0.0024. The coefficient describes the rate at which a material takes up water, and is not a measure of the final water content of the material.

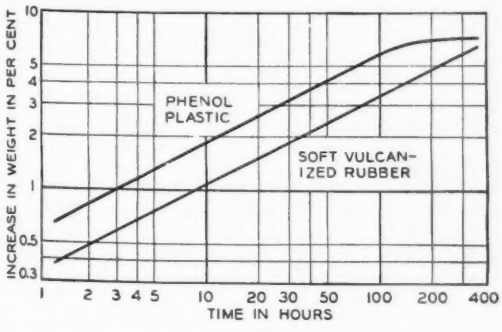


Fig. 2—A logarithmic plot of the sorption of water shows the attainment of equilibrium by the rigid material

It has been demonstrated experimentally for rubber that the logarithm of the sorption coefficient is inversely proportional to the absolute temperature. By using this straight-line relation it is possible to calculate from short-time test data obtained at one temperature the water content of such materials after an extended period of immersion at some different temperature.

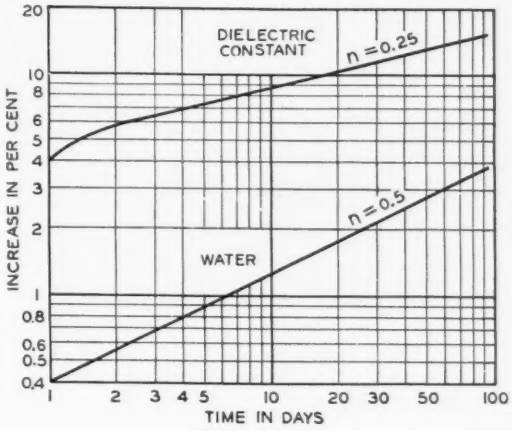


Fig. 3—In distilled water both the water content and dielectric constant of a rubber sheet increase

An important practical application of sorption data is predicting the changes in dielectric constant which accompany the sorption of water. When sheets of soft vulcanized rubber are immersed in distilled water at constant temperature, the increase in weight is proportional to the square root of time, but the accompanying increase in dielectric constant of the material is proportional to the fourth root of time.

These relations are illustrated in Figure 3. There is, however, an initial

period when the dielectric constant increases rather rapidly and during which the power factor reaches a peak. The rapid increase in dielectric constant is believed to result from water adsorbed on the inner structure of the material and the slow increase thereafter mainly to water absorbed by water-soluble substances that are in the material.

Fig. 5—F. J. Biondi measuring the absorption characteristics of a plastic by suspending it from a spiral quartz spring and observing the rate at which the spring elongates

From the relationships of the preceding paragraph, it is evident that the increase in dielectric constant is proportional to the square root of the water content. A curve illustrating this is shown in Figure 4. Although different materials differ in the amounts of water they sorb and in the effect of this water on the dielectric constant, when the relation between dielectric constant and water content is known, a measurement of dielectric constant alone suffices to describe the water-sorbing characteristics of many materials.

Before equilibrium is reached, water sorbed by a homogeneous material such as soft vulcanized rubber does not distribute itself evenly throughout the material but concentrates largely in the outer layers and decreases exponentially toward the center. In many practical cases this exponential distribution proves advantageous; for example, sorption by the insulation on rubber-covered wire. In this case the rubber next to the conductor may remain relatively dry although the amount of water sorbed by the insulator as a whole is appreciable. Wire insulation which has sorbed water in this manner should be considered as graded rather than homogeneous. Curves may be plotted to show the distribution of water in insulation of various kinds and shapes. These curves, with others of the type shown in Figure 4, may be used to calculate the dielectric properties of this type of continuously graded insulation. Information of this character is of practical interest in the telephone plant because of the increasing use of buried wire and the installation of circuits in locations exposed to high humidity.

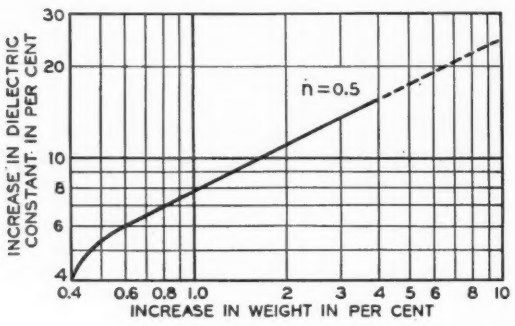


Fig. 4—Dependence of the dielectric constant of rubber sheets on the water content

Terminating Markers: Busy Testing and Line-Choice Selection

By J. W. DEHN
Central-Office Switching Development

BY OPERATIONS described in a previous article,* the terminating marker decodes the number transmitted to it by the terminating sender, and operates a block relay in one of the number groups. Forty block relays with their cross-connection banks, which permit the assignment of any line number to any line switch in the office, are mounted in a bay as shown in Figure 1. Since each block relay represents twenty line numbers, each bay represents 800 line numbers, and a sufficient number of bays are installed to take care of all the lines in the office. The operation of a block relay closes sixty contacts—three for each of the twenty subscriber numbers associated with it. Over one of these three leads, the marker will test the called line to determine whether or not it is busy. If the line is in use, the marker will cause a busy signal to be returned to the subscriber. If the line is idle, however, relays will be operated over the other two leads to direct the marker to the particular crossbar switch to which the line is connected, so that a path may be found between it and the incoming trunk. The lead used for the busy test will then be used to operate the hold magnet of the line called.

Each of the sixty moving contact springs of a block relay is strapped to the corresponding springs of all other block relays of the number group, and is then carried through the number-group connector to the marker. Here they are distributed and connected

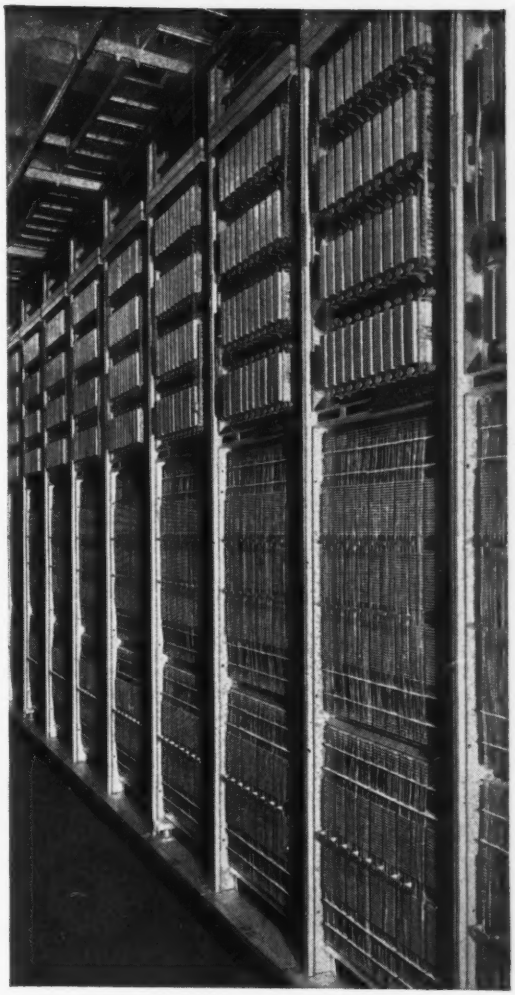


Fig. 1—Block relay bays, each with forty block relays above, and line cross-connecting terminals for their NC *and* NF *leads below*

*RECORD, *July*, 1939, p. 356.

to three moving spring contacts of twenty L relays as shown in Figure 2. The three leads for each line are marked NC, NF, and NS, followed in each case by a number from 0 to 19 to designate the twenty lines of the block relay. The L relays are also numbered from 0 to 19.

The leads from the front contacts of the block relays run to terminal strips—all the NC leads to one set, the NF to another, and the NS to another. The terminal strips for the NC and NF leads are mounted on the frames beneath the block relays as illustrated in Figure 1. These terminal strips are five terminals high and ten wide, and ten of them are mounted in a row across the frames. One such row for the NF leads is shown immediately beneath the block relays. Below it are three banks of multiple-terminal strips, each twenty terminals high. These multiple-terminal banks—somewhat like the banks of a panel selector in appearance—are built up of insulated horizontal metal strips with soldering terminals projecting in line with each terminal of the upper set of terminal strips. Below these is another row of terminal strips for NF terminals like the one above. Two strips—one above and one below the multiple-terminal banks—take care of the NF terminals from the five block relays controlled by one hundred-block relay. Eight pairs of fifty-terminal strips across the bay thus provide for all the block relays on the bay. The ninth and tenth pairs of terminal strips are used for other purposes. Below these cross-connection terminals for the NF leads is a similar set for the NC leads, the main difference being that there are only two banks of multiple terminals for the NC leads instead of the three provided for the NF terminals. Figure 3 shows the arrangement for one twenty-block relay only.

The twenty leads from each of the three multiple-terminal banks associated with the NF terminals are marked TF, HF, and RF, respectively, and numbered 0 to 19 inclusive. They are all carried through the number-group connector to the marker. Cross-connecting jumpers are run from each NF terminal to one of the terminals in one of the multiple-terminal banks. For individual and party lines, the jumper runs to either the TF or RF banks, depending on whether the called station is rung over the "tip" or "ring" conductor, while trunks to a PBX are cross-connected to the HF bank, except the last trunk in a group to any one PBX, which is cross-connected to the RF bank.

The terminals for the NS leads are on the line distributing frame. The terminals to which they are cross-connected on this latter frame are connected to one side of the hold magnets of the primary switches on the line-link frames, and there is thus one terminal for each equipped line in the office. Cross-connecting jumpers are run to associate each NS lead with the hold magnet with which the corresponding line is associated at the line switch. If the line is busy, its NS lead will be found grounded through the sleeve lead of the line. Thus when a block relay is operated, the twenty NS leads brought to the marker will be either grounded or not grounded depending on whether the lines are busy or idle.

As may be seen from Figure 2, the NS leads are extended through back contacts on the L relays—which are unoperated at this point—to the windings of s relays, and the s relays connected to busy lines will be operated by the ground on their NS leads,

while those of idle lines will be left unoperated. The number dialed is indicated by a gound placed on one of twenty leads coming from the unit-digits group of recording relays. These twenty leads follow through a chain of contacts as in the thousands, hundreds, and tens groups of recording relays, only the chain for the unit group relays includes two additional relays, one marked "tens even" and the other "tens odd." This is necessary because a twenty-block includes two sets of ten digits: in the 0 twenty-group for example, are digits 0-19; the first ten, 0-9, are called the even group, and the second, 10-19, the odd group. Similarly 20-29 is an even group and 30-39 an odd group, the term even and odd referring to the tens digit, and this indication is given by contacts on the "tens even" or "tens odd" relays. These "even" and "odd" relays, in turn, are operated by a chain through relays of the tens group, the "tens even" being operated if the tens digit is even, and the "tens odd" if it is odd.

These tweny leads from the units register relays run to the moving spring contacts of the twenty s relays, and one of them will be grounded. If the relay to which this grounded lead is connected is operated, indicating a busy line, the ground will be carried through a front contact on the s relay, and a back contact on the associated HT relay, to a line-busy relay, which causes relays in the incoming trunk to operate and return a busy tone to the calling subscriber. If the line is not busy, the s relay will not operate,

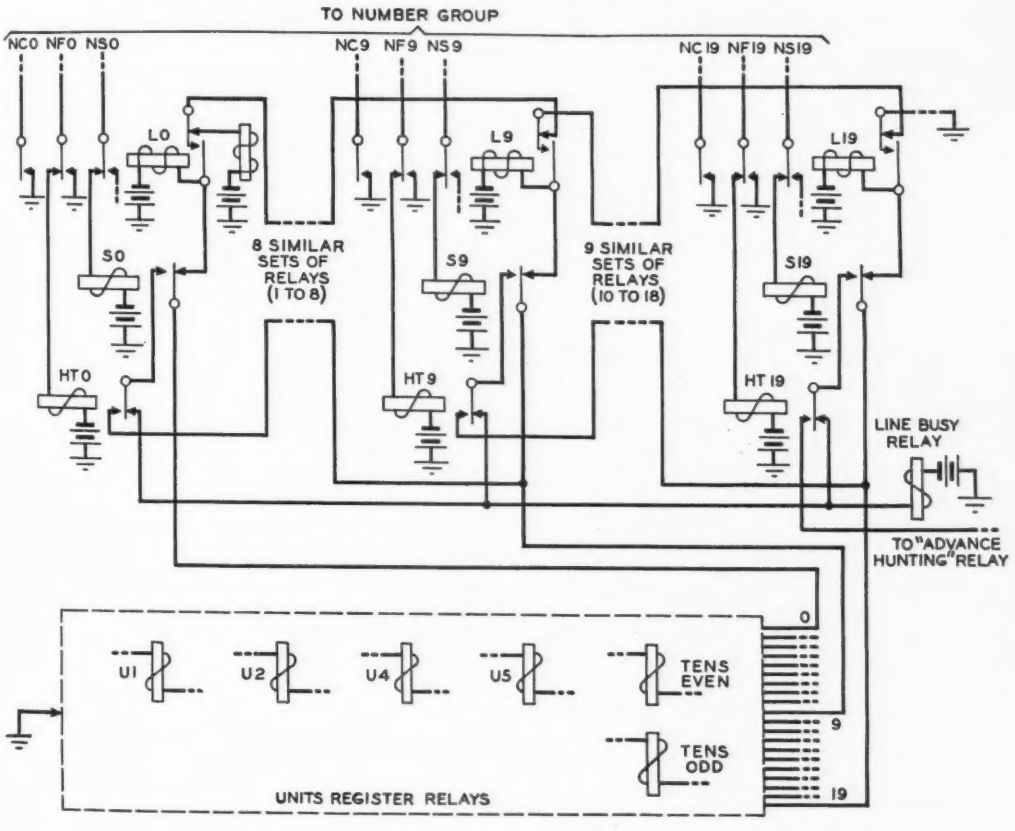


Fig. 2—Simplified schematic of the busy-test circuit of the terminating marker

and the ground will be carried through a back contact of the S relay to operate the associated L relay.

After the number has been registered in the marker a relay is operated that grounds the twenty HF leads brought to it through the number-group connector. This relay remains operated until an L relay operates. If any of the lines of the twenty block are any but the last of a group of PBX trunks, the corresponding NF terminals will be cross-connected to the HF bank, and the ground on these latter leads will thus be carried through the block relay, the number-group connector, and back contacts on the corresponding L relays in the marker, and will operate the corresponding HT relays. All HT relays corresponding to PBX trunks, except the last, will thus be operated. This switches the leads connected to the front contacts of the S relays from the "line-busy" relay to the moving contact of the next S relay, so that instead of returning a busy signal if the first trunk is busy, the ground from the register relays will operate the L relay of the first idle trunk.

Suppose, to take a simple example, that the first trunk of the PBX had 10 as its last two digits and that there were ten trunks in the group—running from 10 to 19. Since the number dialed has 10 as its last two digits, a ground would appear on the 10 lead from the units register. This ground would be carried to the moving contact of the S10 relay, and if this trunk were busy, would be extended through front contacts of S10 and HT10 to the moving contact of S11. If this trunk also is busy the ground will be simi-

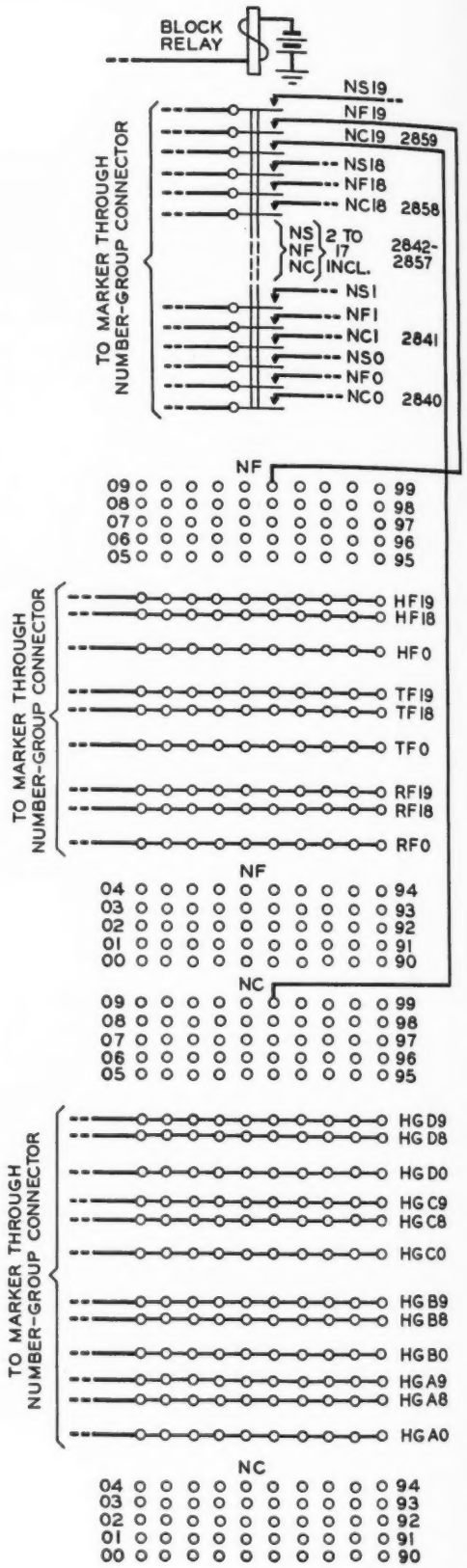


Fig. 3—Simplified schematic of cross-connecting terminals for five block relays, with one of the block relays shown above

larly extended to S12, and so on until an idle trunk is reached, when the ground would be extended through the back contact of that S relay to operate the corresponding L relay. It should be noted, however, that this testing does not pass from one trunk to the next in sequence, but that since all the S and HT relays that are to operate are operated together by the closure of the block relay—the L relay of the first idle line is also operated immediately after the block relay has operated.

If the PBX had been a large one, there would very likely be more than twenty trunks, so that they could not all be reached through a single block relay even if they started with the first line of that block. This situation is taken care of by running the lead from the front contact of the last HT relay to an "advance hunting" relay, which is associated with a group of "hunting progress" relays through which pass the leads from the tens group register relays on their way to the windings of the block relays. If all the trunks in the first block were busy, the ground from the units group of register relays would be carried through the front contact of HT19 to operate the advance hunting relay. This relay would release the block relay already operated, and bring in the block relay with the next group of trunks to the PBX called. At the same time the ground would be removed from the 10 lead from the units register relays and placed on the 0 lead. The leads from the second block relay would now be connected to the marker, and this group would be busy tested in exactly the same manner. By this same method it is possible to test large trunk groups, bringing in one block relay after another as all the trunks of one block are found busy. Should all the trunks in the group be busy, the ground would be extended to the line-busy relay through the back contact of the last HT relay, which will not be operated since the last trunk of a group is connected to the RF rather than to the HF lead.

The operation of an L relay, when a line or trunk is found idle, grounds both the NF and NC leads, and connects the NS lead to relays in the marker that will be used later for "closing through" the talking path. The grounds on the NC and NF leads are carried back through the number-group connector and the block relay to the NC and NF cross-connecting terminals. As already pointed out, the NF leads are cross-connected to one of the terminals of one of these multiple banks—to the RF or TF banks if it is an individual or a party line, and to the HF if it is a PBX trunk. Each multiple bank, however, has twenty rows of terminals, one for each of twenty possible line-link frames, and the cross-connection made will depend on which primary line-link frame the line is connected to.

For convenience in controlling the completion of calls, the line-link frames are divided into groups of four, called "line-choices," and the control leads from only one line-choice at a time are brought to the marker through a line-choice connector. This arrangement parallels that of the number group and number-group connector. There may be as many as twenty line-choices in an office, and the twenty horizontal strips in each of the multiple banks associated with the NF terminals are assigned to the twenty possible line-choices. The cross-connection from any NF lead is thus run to the particular multiple strip that corresponds to the line-choice in which that line is located.

Leads from these multiple banks run to the marker through the number-group connector, and when an L relay operates, the group placed on the NF lead will pass over the cross-connection to the multiple strip—in either the TF, HF, or RF bank—for the line choice on which that line or PBX trunk appears, and will operate a relay in the marker that will bring in the proper line-choice connector.

It is necessary further for the marker to know which particular line-link frame of the line-choice the line is connected to, and the particular row of switches in that frame, so that it can proceed to find an idle path between the incoming trunk and the line. This information is obtained by the cross-connection of the NC lead. As pointed out above there are only two multiple banks associated with the NC leads, but each is divided horizontally into two groups, so that there is the equivalent of four multiple banks, each ten terminals high. Each of these banks represents one of the four line frames of a line-choice, and the ten strips in each group represent the ten rows of switches on each frame. These banks are marked A, B, C, D, rather than by actual frame numbers since they represent different frames depending on the line-choice selected. The jumper from the NC terminal is thus run to the particular level in the A, B, C, or D bank that corresponds to the location of the line on the line-link frame.

The leads from these multiple banks also run back to the marker through the number-group connector. Ground appearing on one of them, from a front contact on the L relay, operates relays that allow the marker to test for idle paths from the incoming trunk to that particular row of switches, and also to operate the proper select and hold magnets to connect the line through.

The Morris Liebmann Memorial Prize

for 1939 *has been awarded to H. T. Friis by the Institute of Radio Engineers in recognition of "his investigations in radio transmission including the development of methods of measuring signals and noise and the creation of a receiving system for mitigating selective fading and noise interference." The award will be presented to Mr. Friis at the Fourteenth Annual Convention of the Institute that will be held in New York in September. Previous Laboratories recipients of this medal are R. A. Heising, J. R. Carson, Ralph Bown, Edmond Bruce, F. B. Llewellyn, W. H. Doherty and G. C. Southworth.*

Time Characteristics of the U-Type Relay

By P. W. SWENSON
Switching Development Department

ON A local call between two subscribers in a crossbar office, nearly a thousand relays are involved. Their sequence of operation and release is determined chiefly by the circuit arrangement, the action of each relay or group of relays depending on the operation or release of some other relay or circuit element before it. At many stages, however, it is essential that the operating or releasing times of certain relays be delayed or hastened to secure the required performance of the circuit. It is important, therefore, that the operating and releasing times of the relays be known and subject to control so that correct operation can be assured under all conditions. With the development of the U and Y-type relays,* therefore, studies were undertaken to determine the various factors affecting operating and releasing times and their range of values, so that curves and tables could be prepared which would enable the performance of these relays to be accurately predicted.

It is possible, of course, to measure the overall releasing or operating times of relays, and to use these results in designing the circuits, but this method has its disadvantages. The releasing time, for example, depends in general both on the number and type of contact springs, and on the height of the stop disk, which is used to provide a small airgap between the armature and core when the relay is operated. To secure releasing times by this purely experimental method, therefore, measurements would have to be made on many combinations of contact springs and of stop-disk heights. In addition, measurements would have to be made on a large number of relays for each combination of springs and disks to establish the minimum and maximum value for each. The more satisfactory procedure is to analyze the time into its various components, and to determine experimentally the range of delay caused by each. When this is done, it is always possible to combine the factors in any desired manner, and to determine the maximum and minimum limits under all conditions.

The releasing time of a relay may be divided into two components known as the electrical releasing time and the mechanical releasing time. The former extends from the time the winding circuit is opened to the time the armature begins to move. The latter is the time required for the armature to move from the operated position to that in which the contacts just open.

The electrical releasing time is really the time required for the flux to decrease from its value when the winding circuit is opened to its value when the pressure of the springs is just sufficient to overcome the pull on the armature. For a relay with no short-circuited winding, this time would be zero if it were not for the eddy currents induced in the mag-

*RECORD, *May*, 1938, *p.* 300 *and p.* 310.

netic material. These currents exert a magnetomotive force tending to maintain the flux, and thus the electrical releasing time may be redefined as the time required for the magnetomotive force of the eddy currents to reduce from its maximum value to a value just small enough to permit the relay to release.

For a given magnetic structure and material, the flux is a definite function of the magnetomotive force maintaining it, and for the U-type relay the relationship is as shown in Figure 1, where the magnetomotive force is given in ampere turns. The form of the relationship between flux and ampere turns depends on whether the exciting current is increasing or decreasing. In the former case, the graph

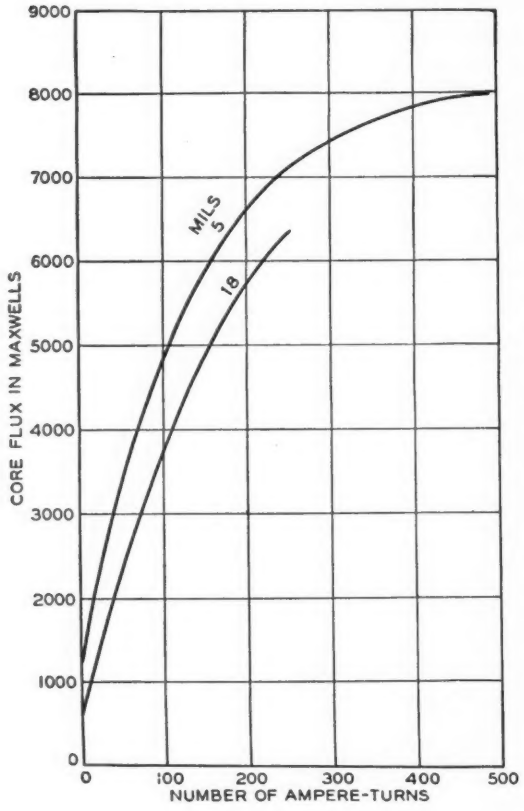


Fig. 1—Demagnetization curves of the U-type relay for 5-mil stop disks, above, and for 18-mil stop disks, below

is called a magnetizing curve, and in the latter—which is the one shown—a demagnetizing curve. The major variable in the magnetic circuit of the U relays under operated conditions is the height of the stop disk. The curves of Figure 1 give the relationship for the two extreme limits of stop-disk heights; the lower one, for an 18-mil disk and 250 ampere turns initial magnetization, represents the conditions for establishing minimum release time; while the upper one, for a 5-mil disk and 500 ampere turns initial magnetization, represents the conditions for establishing maximum release time. For all intermediate values of disk height and magnetization, the curves would lie somewhere between these two.

The time required for the flux to decay over any interval along a demagnetization curve varies as the steepness, or slope, of the curve and as the logarithm of the ratio of the lower to the higher limit of the ampere turns over the interval. If the slope of the curve were the same at all points, that is if the curve were a diagonal straight line, the time would be the same over the interval from 500 to 250 ampere turns as it was from 100 to 50, since the ratio is the same for both intervals. Actually the slope decreases for the higher values of ampere turns, and approaches zero at 500 ampere turns.

As a result of this flattening, the amount of releasing time contributed by a reduction from 500 to 250 ampere turns is very small, so that the overall time depends primarily on the value of ampere turns at which the relay just releases, called releasing ampere turns, which is the lower limit of the interval. The slopes of the two curves, moreover, are very nearly the same, so that the decay time along

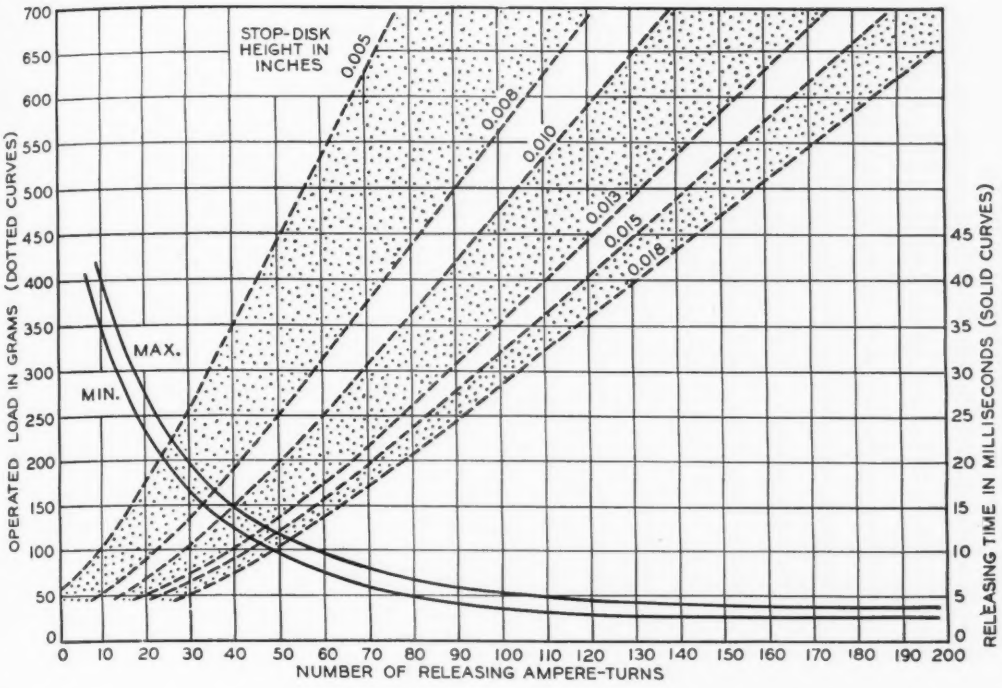


Fig. 2—Curves for the U-type relay showing relationship between releasing ampere turns and electrical releasing time with no short-circuited winding, solid curves, and against operated load for various stop-disk heights, dotted curves

the two curves also is nearly the same, that along the five-mil curve being slightly greater because of the contribution of the section of curve above 250 ampere turns.

It would be possible to calculate the releasing times from these curves if the characteristics of the circuit in which the maintaining current was flowing were known. When the magnetomotive force is due to eddy currents in the magnetic material, however, the current paths are too irregular to permit ready calculation. It is necessary, therefore, to measure the releasing time for various values of releasing ampere turns measured in the winding. Such a set of measured values is shown by the two solid curves of Figure 2. These curves represent the minimum and maximum values of releasing times for all values of releasing ampere turns. Actually, the curves include some mechanical time, since the armature had to move a small distance before opening the contact used to make the measurements. In general the upper curve corresponds to the 5-mil stop disk and 500 ampere turns initial magnetization, and the lower curve to the 18-mil stop disk and 250 ampere turns initial magnetization, but the two curves also cover the small variations from relay to relay. The lower curve is used, therefore, for estimating minimum releasing times, and the upper curve for estimating maximum times.

These time curves thus give the range of electrical releasing times for all U-type relays regardless of the combination of springs and of the height of the stop disks employed. They are not of much value by themselves, however, because they give release time in terms of releasing

ampere turns. It is necessary to know in addition how the releasing ampere turns vary with various combinations of springs and stop-disk heights. Each spring load requires a definite flux to hold it, but the magnetomotive force or ampere turns required to produce this flux will vary with the height of the stop disk, because of the reluctance it introduces into the magnetic circuit. For each of the three nominal heights of stop disks provided, therefore, it is possible to determine experimentally the relationship between spring load and releasing ampere turns. Curves showing this relationship are also plotted on Figure 2, but because a certain amount of variation is unavoidable for a given nominal height of disk, curves for the two limiting values of each of the three nominal heights are shown. These limiting values are 5 and 8 mils for the smallest, 10 and 13 mils for the intermediate, and 15 and 18 mils for the largest stop-disk heights.

The releasing force of the relay depends on the number and types of springs, and tables are available giving the force in grams for each type. For any particular relay, therefore, it is necessary only to add up the loads for the various springs to determine the total load. If, for example, the total load were 300 grams on a relay with a five-mil stop disk, the electrical releasing time would be found by entering Figure 2 at 300 grams on the left-hand ordinate scale, running horizontally to the five-mil load curve, then vertically to the release time curves, and finally horizontally to the right-hand ordinate. Here the maximum time would be found to be some 17 milliseconds and the minimum time, 14 milliseconds. To this, from 1 to 5 milliseconds is added for the travel time. This travel time depends on the spring combination, but is small in any event, so that great precision is not required in determining it. With this set of curves, and tables giving the load of various types of springs and the time of travel from beginning of release to opening of the contacts, the release time may be readily determined for any U-type relay that does not have a short-circuited winding.

To secure longer release times, a short-circuited winding is placed over the relay core. Such windings provide an additional circuit of much lower resistance for eddy currents. Moreover the time required for the current in this winding to decay may be calculated, since it depends on the ratio of inductance to resistance of the short-circuited winding, and the in-

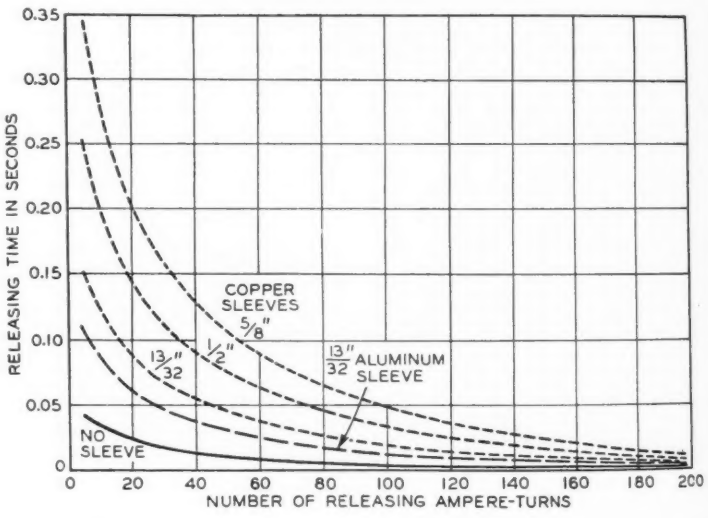


Fig. 3—Electrical releasing time of the U-type relay for various sizes of aluminum and copper sleeves over the core

ductance may be calculated from the demagnetization curves of Figure 1.

In the example taken above, the number of releasing ampere turns, determined from Figure 2, was about 35, and this, as may be seen from Figure 1, corresponds to a flux of about 2700 maxwells for the upper curve. The determination of the delay caused by the short-circuited winding thus reduces to a determination of the time constant of the short-circuited winding as the flux decays from 8000 to 2700 maxwells, which corresponds to a decrease in magnetomotive force from 500 to 35 ampere turns. As already pointed out, this time is proportional to the ratio of the inductance to the resistance. The inductance, which varies with the slope of the demagnetization curve, can be calculated for any point along the curve, and the resistance, which remains essentially constant, can be calculated from the constants of the short-circuited winding. From these values the time for the current to decrease to the desired value may be determined. The total release time will then be that due to the short-circuited winding plus that due to the eddy currents in the magnetic material as given in Figure 2.

The short-circuited windings of the U-type relay usually take the form of a copper or aluminum sleeve placed directly over the core, and concentric with the energizing winding, and the minimum electrical release times for the four sleeves provided, computed as described above, are shown in Figure 3. The bottom curve, which gives the time when no short-circuited winding is used, corresponds to the minimum release-time curve of Figure 2.

Data for estimating the operate times of U-type relays have also been established. This time is mainly dependent on the time required for the current to build up in the operating winding to the value required to operate the relay. Eddy currents in the magnetic material have a less significant although not negligible effect on the operate time. If a short-circuited winding is used, the time constant of this winding will also enter. The longest operate time that can be insured with the U-type relay is around forty milliseconds, while the longest release time is some 125 milliseconds.

Both operate and release-time data are also available for the Y-type relay,* which differs from the U type chiefly in not employing a stop disk. Its armature makes an iron-to-iron contact with the core, and thus holds operated to much lower values of ampere turns. This does not appreciably affect the operate time, but release times as high as 330 milliseconds may be secured.

The data made available by these studies give the relay engineer all the information needed for determining operating and releasing times under all ordinary conditions. One of the valuable features is that it gives maximum and minimum values, and the circuits are always designed for whichever of these values is controlling. When this is done, the variations of individual relays that are employed in a system will not affect the correct operation of the circuit.

*RECORD, *May*, 1938, *p.* 310.

Hearing Tests

Tests of hearing, using musical tones, are available for visitors to both the World's Fairs. The visitor listens through a telephone receiver to a musical tone which he hears in spurts—one, two, or three at a time. Successive groups sound farther and farther away. He writes on his test blank each time how many tones he hears. This is then repeated for other pitches; the tones are 440, 880, 1760, 3520 and 7040 cycles per second. Upon completion the test card is held over a light where the correct numbers appear through the paper. Words "Impaired," "Slightly Impaired" and "Normal or Good" also appear through the paper. The words opposite the

incorrectly recorded numbers describe the condition of hearing. An attendant then places a check mark on the card signifying in private code the sex, color and approximate age of the visitor; and runs it through a photographic recording machine. The photographs so obtained are being used for a survey of hearing undertaken in the Research Department by Dr. J. C. Steinberg.

The photographs shown on this page were taken at the New York World's Fair. Top, the eight entrances to the special sound-proof rooms; center, inside of a room showing five of its seven booths; bottom, recording the test card. The frontispiece, page 369, shows a visitor checking her test card

NEWS of the MONTH

Blank & Stoller

O. E. Buckley, Executive Vice-President, completed twenty-five years of service in the Bell System on July 13

News of the Month

O. E. Buckley, Executive Vice-President of the Laboratories, completed a quarter century of service in the Bell System on the thirteenth of July. Dr. Buckley was graduated from Grinnell College in 1909 with the B.S. degree and remained there as an instructor for a year. He then entered Cornell University where he taught while carrying on his graduate study. From Cornell he received the degree of Doctor of Philosophy in 1914; and immediately entered the Engineering Department of the Western Electric Company as a research physicist.

At that time the early work on wireless telephony was proceeding rapidly, and Dr. Buckley was assigned first to the study of mercury-arc oscillators and later to the development of power tubes and to the improvement of vacuum technique generally, to which he made several important contributions. Shortly before the United States entered the World War, he was assigned to a group who were investigating submarine detection problems for the Navy and commissioned in the Signal Corps Reserve. In July, 1917, he was called to active service. In September, with the rank of Major, he went to Paris where he was given charge of the Research Section of the U. S. Signal Corps. A year later he returned to Washington as a representative of the A. E. F. on Signal Corps matters.

After demobilization Dr. Buckley returned to the Laboratories and at the suggestion of the late Dr. Arnold began an investigation of submarine telegraph cables. Within a few months he had recognized the possibility of greatly increasing the message capacity of such cables by the application of new materials and techniques. Among these materials were the new iron-nickel alloys. So encouraging were the prospects, that backing for the work was forthcoming and development work begun, the first fruit of which was the Western Union's 1924 cable from New York to the Azores. Although permalloy provided, through its high magnetic permeability, a means of increasing the inductance of the cable, the mere wrapping of this metal around the copper conductor of the cable was far from providing a practical solution of the problem of high-speed ocean telegraphy. To achieve this required the solution of very many subsidiary problems concerned not only with the making of a cable but also with the transmission of signals over it and with the means for its practical operation. Work on all these phases of the problem of the loaded cable was actively pursued in the Laboratories under Dr. Buckley's direction; and he also maintained close contact with the manufacturers in England while the cable was being made. Shortly after the cable had been turned over for engineering test, 1900 letters were being transmitted—a radical improvement over the 500 letters a minute of corresponding non-loaded cable then in use.

The importance of a magnetic loading material led Dr. Buckley to direct a series of researches toward a better understanding of ferromagnetism and also toward the development of better magnetic materials for specific applications. Numerous publications by his associates and himself have disclosed the results of this work. Other researches under his guidance concerned discontinuities in magnetization, and conduction of current in vacuum tubes and solid conductors.

In 1927 Dr. Buckley was made Assistant Director of Research; and in 1933 following Dr. Arnold's death he became Director of Research, which position he held until his election to the vice-presidency in 1937. The honorary degree of Doctor of Science was conferred on Dr. Buckley by Grinnell College in June, 1936. He is a member of the National Academy of Sciences, of the Acoustical Society of America and of The Franklin Institute, and a fellow of the American Institute of Electrical Engineers and of the American Physical Society. Recently he was appointed a Member at Large of the Executive Committee of the Division of Physical Sciences of the National Research Council.

* * * * *

For the past few years the operating companies of the Bell System have been accepting more and more invitations for talks and demonstrations of the popular scientific aspects of telephony before schools, service clubs and similar groups. J. O. Perrine, Assistant Vice-President of the American Telephone and Telegraph Company, who has had wide experience in lecturing, recently arranged a conference for those concerned in this work. This was held in New York from June 5 to 9, and attended by 65 men from the various operating companies.

The conference spent almost three days getting a broad picture of the work of the Laboratories,

visiting also the field laboratories in New Jersey. These inspection trips were arranged by L. S. O'Roark and G. F. Fowler. On June 6 the group gathered in the auditorium where Dr. Buckley welcomed them and described the work of the Laboratories. They were then guided by W. C. F. Farnell, B. A. Clarke, C. D. Hanscom and G. F. Fowler on a tour of inspection which included D. G. Blattner's acoustic laboratory where the work was described by R. L. Hanson; B. L. Clarke's microchemical laboratory, H. W. Hermance and H. V. Wadlow; G. W. Elmen's magnetics research laboratory, D. M. Chapin; and J. L. Dow's manual and ringing laboratory, L. J. Stacy. They also saw the ceramics, frequency standards, and microscopic laboratories where the work was described by the guides.

For luncheon the groups with their guides gathered in the twelfth-floor conference room where they were joined by Messrs. Buckley, O. B. Blackwell, A. F. Dixon, R. L. Jones, Harvey Fletcher, W. Wilson, G. B. Thomas, Ralph Bown, R. A. Haislip, H. W. Dudley and F. S. Goucher, and as members of the conference representing the Laboratories, John Mills, L. S. O'Roark, M. B. Long and P. B. Findley. Following luncheon, there were talks and demonstrations by Dr. Goucher and by Mr. Dudley; an inspection of C. S. Gordon's insulated-wire testing laboratory where the work was discussed by F. F. Farnsworth; of J. L. Dow's crossbar switching laboratory, W. Rupp; and of J. R. Wilson's vacuum tube development laboratory, V. L. Ronci and R. C. Winans.

On June 8, the conferees were taken to the radio development laboratory at Holmdel, the transoceanic radio-telephone station at Lawrenceville, the Princeton repeater station and the outside plant development laboratory at Chester. At Holmdel, wave-guide transmission was described by G. C. Southworth, A. E. Bowen, A. G. Fox and A. P. King; the musa laboratory, by K. G. Jansky and C. F. Edwards; ultra-short-wave transmission, C. R. Englund, W. W. Mumford, A. B. Crawford and W. M. Sharpless; rectifier studies, R. S. Ohl; and rotatable rhombic antenna system, L. R. Lowry. A field tour of the property was conducted by Mr. Lowry and A. C. Beck and the facilities of the main laboratory explained by Mr. Mumford. General arrangements for the visit at Holmdel were made by H. T. Friis. At Chester, R. A. Haislip and C. A. Chase described the work.

On June 9 the conferees gathered at the Graybar-Varick Building where they visited M. E. Strieby's high-frequency transmission laboratory and heard J. M. West discuss coaxial amplifiers; J. F. Wentz, coaxial cables; K. E. Gould, ultra-sensitive measuring apparatus for broad-band systems; and C. L. Weis, television amplifiers, monitors and transmission characteristics. At R. A. Heising's crystal research laboratory, S. C. Hight demonstrated the underlying characteristics of quartz crystals. In J. H. Bell's telegraph development laboratory, late developments in equipment and systems were discussed by Mr. Bell, W. A. Phelps, W. M. Bacon, W. T. Rea and C. A. Dahlbom. In B. W. Kendall's carrier and repeater laboratory, modern repeaters and carrier-system developments were covered by O. D. Engstrom, R. L. Case, J. W. Beyer, G. W. Cowley, J. P. Kinzer, H. S. Black and J. B. Maggio. The trip through these two laboratories was arranged by S. W. Shiley with F. H. King, H. F. Winter and R. C. Hersh as supplementary guides. In a laboratory of W. A. MacNair, magnetic-tape recording was demonstrated by F. A. Coles. The transmitter and receiver development laboratory was explained with suitable demonstrations by W. C. Jones, W. L. Tuffnell, R. H. Griest, R. C. Miner and W. G. Turnbull. The conference concluded that evening with a dinner at the Harvard Club at which Dr. Jewett spoke.

* * * * *

WILLIAM WILSON, Assistant Vice-President, completed twenty-five years of service in the Bell System on the twenty-ninth of June. After graduation from the University of Manchester in England from which he received the B.Sc. degree in 1907 and the M.Sc. degree a year later, Dr. Wilson conducted research in radioactivity

William Wilson

W. J. SHACKELTON

of the Telephone Apparatus Department completed thirty years of service in the Bell System on the third of July

WILLIAM FONDILLER

of the Telephone Apparatus Department completed thirty years of service in the Bell System on the twelfth of July

C. G. SPENCER

of the Central Office Switching Development Department completed forty years of Bell System service on June 27

and electronic physics in the Universities of Manchester, Cambridge, and Giessen (Germany). He first came to this continent in 1912 to become Lecturer in Physics at the University of Toronto. While there he received the degree of Doctor of Science from his alma mater.

Two years later Dr. Wilson joined the Engineering Department of the Western Electric Company, to work on electronics as a member of its research laboratory. In 1915 he was placed in charge of the radio receiving station set up in San Diego to listen for signals from the experimental transmitter at Arlington, Virginia. After the successful completion of these tests, a program of further research was projected, in which Dr. Wilson was placed in charge of the research and development work on vacuum tube filaments. During the latter part of the war, he had charge of the Western Electric Company's manufacture of vacuum tubes for the United States Government, and in 1918 became responsible for vacuum tube research, development, design and manufacture. Continuing these responsibilities up to October, 1933, he was intimately associated with the high-vacuum tube through nearly the whole of its history.

In 1925 Dr. Wilson also took charge of the radio research activities of the Laboratories which have borne fruit in short-wave radio-telephone systems for communication with Europe and transatlantic liners and in improved ultra-short-wave systems. In 1927 he was made Assistant Director of Research. In 1934 there was added to his responsibilities the supervision of the Laboratories' research investigations into problems of communication by wire. Late in 1936, he was appointed Assistant Vice-President in charge of personnel and publication.

Dr. Wilson has been active as a Fellow of the Institute of Radio Engineers, serving as a member of the Papers Committee, the Standards Committee, and the Awards Committee as well as the Board of Editors. At various times he has been Chairman of these Committees, and for three years he was a Director of the Institute. Dr. Wilson is a member of the American Institute of Electrical Engineers, representing it on the Sectional Committee on Radio of the American Standards Association. He is also a Fellow of the American Physical Society, and a member of the Executive Committee of the American Section of the International Scientific Radio Union.

* * * * *

UNDER THE AUSPICES of the Graybar Electric Company, some seventy distributors of electrical hearing aids met in New York, June 26 to 30, to learn more about these devices and their scientific background. Meetings were held in the auditorium of the Laboratories on June 27 and 28 at which W. C. Jones discussed the development, operation and maintenance of Western Electric audiphones and Harvey Fletcher gave a talk and demonstration of *Auditory Patterns.* On an inspection trip through the Laboratories the visitors saw the historical museum; some acoustic laboratories, and Oscar, all demonstrated by J. B. Kelly; microphonic action

studies, J. R. Haynes; magnetic materials laboratory, D. M. Chapin; microscopic laboratory, Miss A. K. Marshall; dry-cell testing, J. H. Bower; mechanical wear laboratory, W. A. Krueger; and materials testing laboratory, I. V. Williams. The inspection trip guides were B. A. Clarke, C. D. Hanscom, W. C. F. Farnell and G. F. Fowler. Auditorium facilities were handled by J. M. Reilly and P. Venneman and buffet lunches were served both days under the supervision of Mr. Reilly and W. J. Hahn. L. S. O'Roark and G. F. Fowler were in charge of general arrangements.

* * * * *

AMONG THE engineers and research workers who visited the Laboratories during April and May were: from *Australia*, Dr. G. H. Briggs, officer in charge of the Section of Physics of the Australian National Standards Laboratory; *Canada*, J. H. Trimmingham, Chief Engineer, Power Corporation of Canada, F. H. Sanders, National Research Council, Ottawa, John Woslyng, Cardston, Alberta, and Lionel Judah, Montreal; *England*, Sir William Bragg, Director, Royal Institute of Great Britain, Sir Samuel Turner, Turner and Newhall, Ltd., Rochdale, Dr. Dorothy Wrinch, Mathematical Institute, Oxford University, B. B. Grace, Standard Telephone and Cables, Ltd., London; *Finland*, T. K. Laakso; *France*, Leon Brillouin, College of France and L. Deveaux, Le Materiel Telephonique, Paris; *India*, N. B. Bhatt; *Japan*, Ryoxo Nakamura, Technical High School, Nagaoka; *Norway*, O. Hassel and Christian Finbak, University of Oslo; *Philippine Islands*, Ernesto B. Ledesma, General Commercial Manager, Philippine Long Distance Telephone Company, Manila; *Poland*, R. A. Brykscynski and Tadeusz Korn, Polish Institute of Telecommunications; *South Africa*, Albert Coyne, Technical College, Capetown, and Captain G. Allan King, South African Instructional Corps; and from *Sweden*, Walter Ohman, Nitroglycerine Corporation, Gyttorp, and H. Trebler, Chief Engineer, Ericsson Telephone Company.

* * * * *

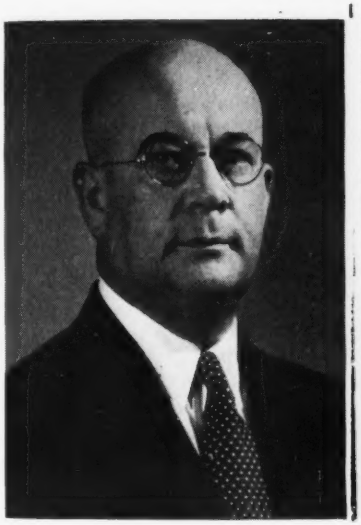
DR. BUCKLEY gave a talk at the Long Island Area Conference of the New York Telephone Company, held at Montauk on June 16. He described certain Laboratories' developments of particular interest to operating companies. On June 13, with several of his staff, he visited the Western Electric Company at Kearny.

W. WILSON and G. B. THOMAS attended the Bell System Personnel Conference held from June 12 to 16 at Osterville, Massachusetts.

AT THE SPRING meeting of the Edward J. Hall Chapter of the Telephone Pioneers of America, W. Wilson was elected president; R. A. Haislip, a member of the Executive Committee; and H. J. Delchamps, R. J. Heffner and R. A. Shetzline, members of the Membership Committee.

W. C. F. FARNELL spent the week of June 19 at the Edison Institute Museum in Dearborn, Michigan, identifying the telephone instruments acquired by the Institute for their exhibit.

F. E. DRAKE was in Washington in connection



S. W. SHILEY

of the Toll Development Department completed thirty-five years of service in the Bell System on July 31

A. G. KINGMAN

of the Patent Department completed thirty-five years of service in the Bell System on the thirtieth of June

C. R. BARNEY

of the Telephone Apparatus Department completed thirty-five years of service in the Bell System on the ninth of July

with a demonstration of selective ringing as applied to radio-telephone equipment for marine service.

D. K. MARTIN and H. B. FISCHER visited Kansas City to attend a meeting of the radio range subcommittee of the Radio Technical Committee for Aeronautics. Mr. Fischer also attended the meeting of the National Advisory Committee for Aeronautics at Langley Field, Virginia.

F. C. WARD was in Baltimore on June 29 to inspect a 100-watt radio-telephone equipment installed on the steamship *Sea-Kay*.

A. K. BOHREN visited the United Air Lines Communications Laboratory in Chicago to test a new radio-telephone transmitter designed for air transport service.

T. H. ROBERTS

of the Central Office Switching Development Department completed forty years of Bell System service on July 20

E. W. HANCOCK

of the Central Office Switching Development Department completed thirty-five years of Bell System service on July 29

W. J. ADAMS and A. K. BOHREN attended a conference at Camden with eastern manufacturers of air-line radio apparatus and with representatives of the Civil Aeronautics Authority. At this conference a revision of the testing requirements for government approval of aircraft radio equipment was discussed.

A MEETING of the Radio Technical Committee for Aeronautics held at the new experimental station of the Civil Aeronautics Authority at Indianapolis was attended by E. L. Nelson, D. K. Martin and H. B. Fischer.

F. E. NIMMCKE visited St. Louis to inspect the installation and adjust the 14C radio transmitter and 309B radio-telephone equipment purchased by the Police Department. The 14C transmitter is used for interzone telegraph work with other police organizations, while the 309B equipment is used for communication with the radio patrol cars.

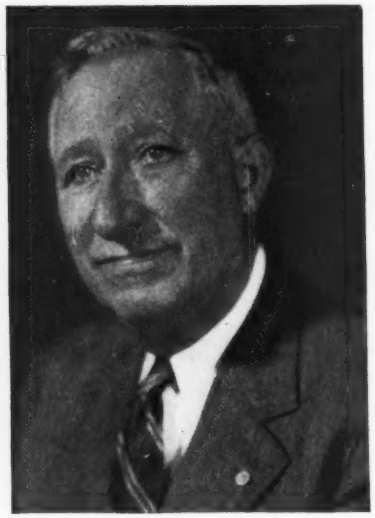
W. L. BLACK and E. T. MOTTRAM attended the sessions of the convention of the National Association of Broadcasters during the week of July 10 at Atlantic City.

W. FONDILLER and H. H. GLENN made a trip to Point Breeze to study certain manufacturing processes.

AT THE ANNUAL meeting of the Southern Textile Association, in a paper on fibre research, E. R. Schwarz, M.I.T. professor of textile technology, said, in part: "It is a sad criterion of progressiveness when we have to go to the Bell Telephone Laboratories for current infor-

W. C. JORDAN

of the Central Office Switching Development Department completed thirty years of Bell System service on July 19



JOHN MURRAY

of the Plant Operation Department completed thirty years of service in the Bell System on June 15

mation on moisture effect on textile fibers. This is a field of investigation which is relatively a sideline with them, but their published results have made available information of importance to the textile industry and their efforts have resulted in the training of an A. C. Walker, now chairman of the Drying Research Committee of the United States Institute for Textile Research. A sign of progress is the readiness of the textile industry to recognize such a man and to use his talents."

At Forked River and Lawrenceville, New Jersey, W. E. Mougey, R. P. Ashbaugh, J. H. Ingmanson, V. J. Albano, G. N. Vacca and W. E. Campbell, with C. E. Baldwin of the Long Lines, examined samples of buried cables with different types of protection.

O. S. Markuson of the Cable Development Department at Point Breeze came to New York on matters pertaining to carrier-cable problems.

C. H. Amadon, in Montreal, discussed methods of pole-line inspection and maintenance.

R. H. Colley attended the meeting of the Executive Committee of the American Wood-Preservers' Association held in Chicago in June. He also held conferences with producers in Minneapolis on current production and treatment of cedar poles; and with the staff of the Forest Products Laboratory at Madison on timber testing and timber preservation.

H. Baillard was in Norwich, Connecticut, in connection with a trial installation of negative coefficient thermistors in the New London-Danielson "A" cable.

J. H. Gray was at Forked River, New Jersey, in connection with the installation for experimental purposes of several designs of small buried cable and buried wire.

Recently, W. J. Lally, J. M. Hardesty and S. M. Sutton, with S. A. Haviland of the American Telephone and Telegraph Company, were in Philadelphia on matters pertaining to a trial of an improved method of constructing underground conduit.

E. W. Niles and F. S. Corso, together with D. G. Scrantom, A. Mohr and C. A. Hallam of the Western Electric Company, visited the Dahlstrom Metallic Door Company at Jamestown, New York, to observe the production of sheet-metal shapes.

R. V. Terry went to the Haydon Manufacturing Company at Forestville, Connecticut, in connection with switchboard position clocks. He also visited the Standard Electric Time Company at Springfield to discuss an electric stop clock for surface observing.

Tools and methods for replacement of insulators on step-by-step switches were discussed by W. T. Pritchard, G. Garbacz and L. E. Dickinson at Shamokin and Kulpmont, Pennsylvania.

Members of the Laboratories Who Completed Twenty Years of Service in the Bell System During April, May and June

Apparatus Development Department

J. L. Agterberg	May 19
B. O. Browne	June 16
Robert Burns	April 28
H. E. Coffin	June 4
F. J. Given	May 19
F. A. Kuntz	May 12
A. S. Miller, Jr.	June 25
R. B. Miller	April 21
H. O. Siegmund	June 24
Leonard Vieth	May 12
Horace Whittle	May 23

Research Department

R. H. Galt	May 15
Eugene Peterson	May 22
V. L. Ronci	June 11
R. F. Squires	June 30
George Wolff	April 7

Transmission Development Department

J. E. Kenzig	May 15
J. T. O'Leary	May 14
J. F. Wentz	May 12

Systems Development Department

G. C. Berndt	June 30
F. G. Colbath	May 5
P. B. Fairlamb	May 7
Charles Gittenberger	June 16
C. W. Green	April 15
J. M. J. Harriot	June 2
C. M. Hemmer	June 23
A. L. Hogan	April 7
J. L. Hysko	May 22
D. H. Mann	June 2
L. J. Stacy	April 8
U. P. Thorp	June 23
P. V. Welch	April 4

Bureau of Publication

M. B. Long	May 1

Patent Department

G. T. Lewis	May 19

Plant Department

Michael Bandura	April 10
J. W. Hillier	April 21
James O'Farrell	May 27

R. O. MERCNER, Research Laboratory Engineer, died suddenly on July 2. Mr. Mercner attained his technical training in night courses at Temple University and The Franklin Institute in Philadelphia and Pratt Institute and Brooklyn Polytechnic Institute in Brooklyn. He entered the Bell System as a draftsman with the New York Telephone Company in 1915. Eight months later he joined the Engineering Department of the Western Electric Company where, with the Apparatus and Research drafting groups, he engaged in the designing of telephone apparatus. In 1919 he transferred to the Physical Research Department and participated in the development of vacuum tubes and radio equipment.

Since 1922, Mr. Mercner had been in charge of design and drafting work in the Research Department. This work involves apparatus used in research studies pertaining to telephone transmission, such as transoceanic telephone transmitters and receivers, telephoto picture machines, television equipment, submarine cable terminal equipment, and also apparatus used in the telephone plant. Frequently the design of such equipment concerns not only the question of operation but also that of protection of human life, such as in the case of high-voltage rectifiers, radio transmitters, high-speed machinery and chemical apparatus. For the design of much of this type of equipment Mr. Mercner was largely responsible and many valuable design features originated with him.

* * * * *

A. E. PETERSON, who retired in 1931 after thirty-eight years of service in the Bell System, died suddenly on the tenth of July. Mr. Peterson became a member of the Western Electric Company in 1893 and worked for a number of years as a tool and die maker. In 1913 he went to Hawthorne to take charge of the manufacturing operation in connection with the one-piece lug holder for the telephone desk stand. Formerly made from several pieces, the lug holder was redesigned to be manufactured from one piece and Mr. Peterson, previous to going to Hawthorne, had had a prominent part in the development of the tools and rolling process. In 1920 he returned to the Development Shop and in 1923 was assigned to the Transmission Instrument Department where, until his retirement, he worked as a special mechanic on recording and reproducing apparatus such as the acoustic phonograph, electric recorders, reproducers and loud speakers.

* * * * *

PAUL KOHNERT, a former instrument maker in the Development Shop who retired in 1933 after twenty-three years of service, died on June 26. Mr. Kohnert was born in Alsace-Lorraine and came to this country in 1895. From then until 1910 when he joined the Western Electric Company he was with several other concerns, the last of which was the Sunray Arc Lamp Company where he spent a year and a half.

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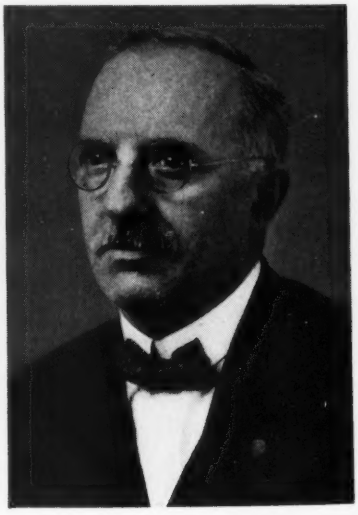
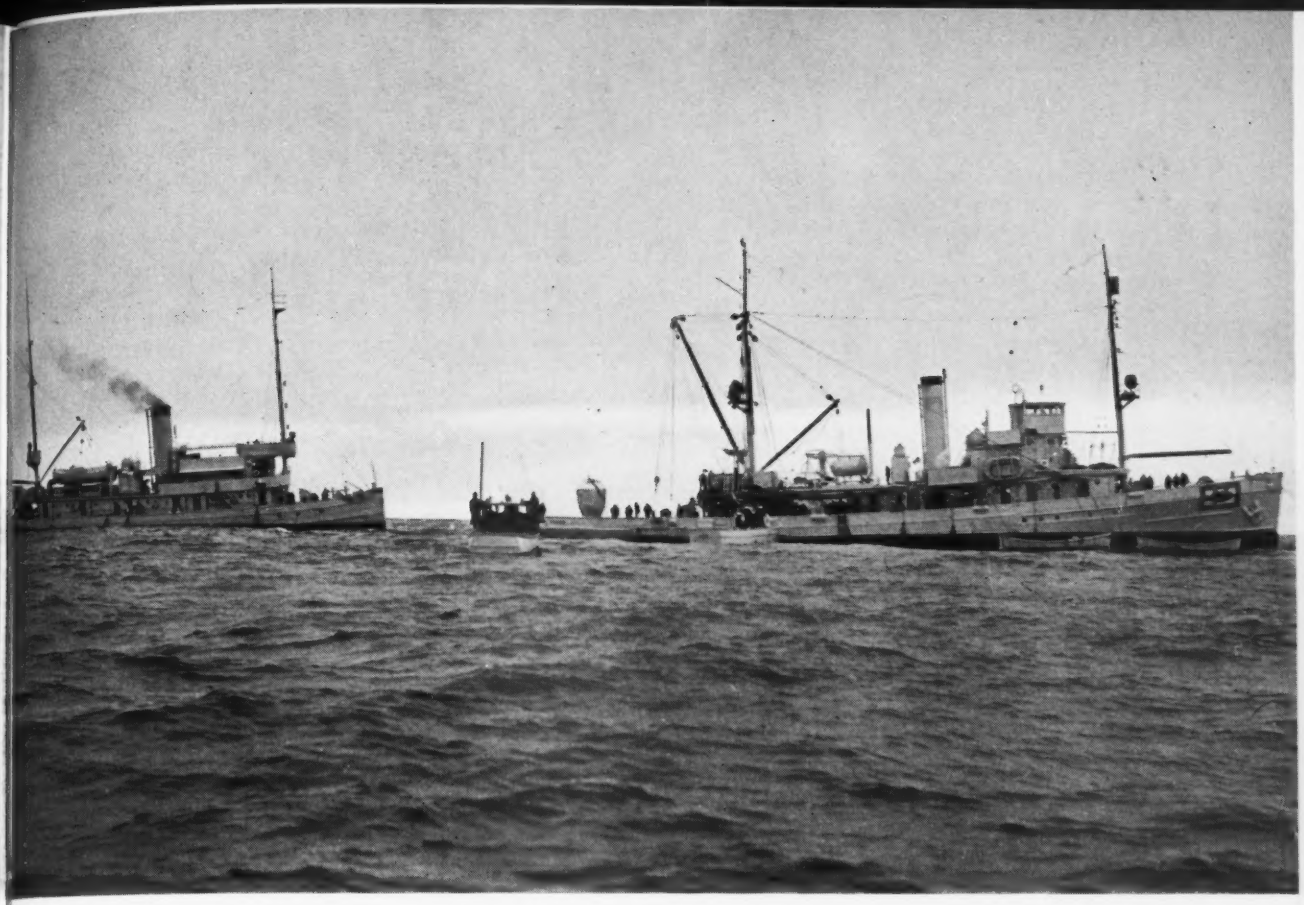
PAPERS ENTITLED *Rockwell Hardness of Cylindrical Specimens* by W. E. Ingerson, *Analysis of Rockwell Hardness Data* by W. E. Ingerson and R. L. Peek, Jr., and *Disintegration of Face Brick by Crystallization of Soluble Salt* by J. M. Hardesty were presented at the session for methods of testing of the annual convention of the American Society for Testing Materials held in Atlantic City from June 26 to 30. H. G. Arlt took part in a Symposium on Paint Testing during which he spoke on *The Conical Mandrel*

A. E. Peterson, 1873-1939

R. O. Mercner, 1893-1939



Paul Kohnert, 1873-1939



How the Telephone Carried News of the *Squalus*

as told by EMERSON W. HUNT *of the New England Telephone Company*

PERHAPS telephone operators develop some sort of a sixth sense that tells them when their training and skill are going to be needed. Perhaps it was that sixth sense that told Mary Quinn, Acting Chief Operator at Portsmouth, N. H., for the New England Company, that behind the unusually heavy volume of calls going through her switchboard to and from the navy yard across the river on the morning of May 23 lay trouble—trouble that would shock the entire world when news of it sped through her board to newspapers and radio studios across the entire country.

There were calls to and from Washington; urgent calls to other navy yards; to the torpedo station at Newport, R. I., where divers are trained for their dangerous occupation; and calls to and from high ranking officers of the Navy.

Concerned by the steady increase in these urgent calls, Miss Quinn called the signal officer at the navy yard and asked whether anything was wrong. She was assured that there was no trouble of any kind. Naturally, the Navy is reluctant to admit difficulties with her submarines until all facts are known, since it realizes that early and incomplete reports may be misinterpreted by the public.

Still the calls increased. So, late in the morning, Miss Quinn called the yard again, assuring the signal officer that her's was not an idle curiosity, but a desire to help if help were needed. She pointed out that if there was trouble at the yard that would require a large volume of calls, she would have to call in more operators and make her plans for additional help.

The signal officer hesitated, still reluctant to admit trouble. Then he said: "You had better call in all the operators you can get."

It was not until Miss Quinn had talked with the heads of the company's traffic department in Boston, and operators had been ordered to Portsmouth from other New Hampshire cities and towns, that telephone people—Miss Quinn included—learned what was wrong at the yard. Not until then did they hear that the submarine U.S.S. *Squalus* lay somewhere at the bottom of the sea off the New Hampshire coast, with fifty-nine men aboard and with two compartments so filled with water that she was unable to rise.

While additional operators were on their way to Portsmouth from other points, the heads of the various departments of the company were working

together to anticipate the communications demands that would be made. For instance, the Navy's needs for service were checked at the beginning and at various times until the rescues were completed, but, beyond supplying one private line, the telephone company was not called on for extra service for the Navy Department.

However, nearly 300 newspaper men, broadcasters, and photographers, who began arriving in numbers by early evening of the first day, were in urgent need of telephone facilities. To provide telephones for an improvised press room, familiarly known to the reporters as the "madhouse," plant men immediately began stringing wires across private yards—with the permission of the owners, of course. At the request of one reporter, a telephone was installed in his automobile which was parked outside the "madhouse," and for the duration of his stay in Portsmouth, this car was his private office.

The commercial people at Portsmouth also were on duty throughout the night taking orders for telephone, telephotograph, teletypewriter, and program transmission services wherever they were needed. In most cases, these orders were completed in less than twenty minutes from the time of receipt. These included many requests for special radio program transmission circuits connecting with some of the major networks of the East, and direct telephone lines to Boston, New York, and elsewhere. In this connection, the Long Lines provided special circuits between Portsmouth and New York for the National Broadcasting Company and the Columbia Broadcasting System.

The New England Company also transported a portable radio-telephone set to lonely Star Island, situated about five miles from the spot where the *Squalus* lay, so that in the event of bad weather, newspaper men might use this equipment to send news ashore without the necessity of making the long trip to the navy yard at Portsmouth. News transmitted by this set was received by similar portable equipment on the grounds of the company's radio-telephone station at Green Harbor, Mass., which is connected by a wire line with Boston. One of the most interesting calls passing over this radio-telephone bridge with the shore was made to a newspaper office in New York by a reporter whose boat became disabled offshore.

A further aid to the press was provided by the company when it located boats and yachts, equipped with radio-telephone equipment, which could be chartered and used in reporting the news from the actual scene of the sinking. Two boats were chartered by newspapers through this arrangement and provided with telephone service with the shore through the radio-telephone station at Green Harbor.

The telephone people also listened to all radio broadcasts and statements from the Navy, trying to anticipate from the progress of the rescue work what they could do further to expedite the transmission of the story of the *Squalus* to the world.

As the Navy proceeded with the rescue of the thirty-three surviving men aboard the submarine, telephone traffic at Portsmouth increased from a normal load of 850 calls to a peak of 1,400 calls on the first day, and 1,600 calls on the second day after the news story broke. While the telephone employees at Portsmouth had seldom had a request for the transmission of photographs over telephone facilities previously, thirty-two pictures were sent out by telephoto on the first day after the *Squalus* disappeared.

Although the *Squalus* sank some distance offshore, the coöperation between the Navy, the Coast Guard, the press, radio stations, and the telephone company made it possible for each step in the process of rescuing the survivors to be known throughout the United States and the world nearly as swiftly as it was learned by the men at the scene. The rescue chamber had hardly appeared at the surface beside the rescue ship *Falcon*, carrying to the sunlight and fresh air of a soft May afternoon the first two men who had faced death in the darkness for two days, before it was known from coast to coast and in the principal cities of Europe that, for the first time in history, men had been rescued from a submerged and helpless submarine. And telephone people had done their part to help tell the story.

for Measuring Elongation of Attached Films. He also showed the motion picture *Physical Testing Methods for Organic Finishes*. W. J. Farmer attended the convention in connection with a magnetic strain gauge developed by the Laboratories that was shown in the Exhibit of Testing Apparatus. This gauge is used to measure strain on cables and similar structures under wind vibrations and movement due to temperature. It is not only capable of showing rapid vibrations up to twenty cycles per second but may also be used to record movements at very slow rates, say one cycle of movement in twenty-four hours. Others attending various committee and general meetings included R. Burns, W. A. Evans, F. F. Farnsworth, C. H. Greenall, C. D. Hocker, J. W. Kennard, J. R. Townsend and W. W. Werring. Mr. Townsend acted as co-chairman of the session on Non-Ferrous Metals and Chemical Analysis.

Miss M. S. Felton, 1902-1939

* * * * *

Miss M. S. Felton of the Switching Research and Station Instrumentalities Department died on June 27. Before joining the Bell System in 1920, Miss Felton spent three years with the Pomeroy Company as a typist and bookkeeper. She then became a typist in the Operating and Engineering Department of the American Telephone and Telegraph Company. Two years later she transferred to the Equipment Development Group of the Department of Development and Research where she was first engaged in general clerical and typing work and then became an engineering assistant in the Station Instrumentalities Group where she remained after the consolidation of the D and R with the Laboratories in 1934. In the work of this group Miss Felton was of material assistance in laboratory studies, analysis of data and in field surveys.

* * * * *

R. L. Hanson visited the Radcliff office of The Bell Telephone Company of Pennsylvania in Philadelphia to investigate noise reduction in that office.

C. F. Wiebusch presented a paper on *The Spring Clutch* before the Applied Mechanics Division of The American Society of Mechanical Engineers held at Columbia University on June 14.

In the June issue of the *Journal of The Franklin Institute* is published an article by Homer Dudley, R. R. Riesz and S. S. A. Watkins entitled *A Synthetic Speaker*, which describes the Voder now being demonstrated at the New York and San Francisco Fairs. The first public showing of this apparatus was made at The Franklin Institute on January 5, 1939.

R. L. Miller is the author of an article entitled *Fractional-Frequency Generators Utilizing Regenerative Modulation*, published in the July issue of the *Proceedings of the I.R.E.*

R. A. Heising delivered a talk, *Radio Extension Links*, before sections of the Institute of Radio Engineers at Los Angeles on June 20, at Portland on July 6, and at Seattle on July 10. He also attended the convention of the Institute held in San Francisco from June 27 to 30 and, as President, addressed the convention on Institute matters. At this convention also were presented papers entitled *Recent Advances in Receiving Equipment for Transoceanic Telephony* by F. A. Polkinghorn and *Solar Cycle and the F_2 Region in the Ionosphere* by W. M. Goodall.

K. K. Darrow has been appointed a member of the Committee on Education and Participation in Science formed by the American Philosophical Society to carry on an amateur science survey in Philadelphia. This is part of a survey of amateur science and scientists being undertaken by the Carnegie Institution of Washington in connection with its adult education program. The Institution has made a special grant to the Philosophical Society for this work.

R. L. Elliott and N. E. Newton of the Northern Electric Company visited the Laboratories to discuss current problems.

New developments in teletypewriters were discussed by T. L. Corwin with engineers of the Teletypewriter Company in Chicago.

Among members of the Laboratories who visited the Western Electric Company at Hawthorne were R. R. Williams, A. R. Kemp, W. J. Clarke and J. R. Townsend who discussed molded plastics manufacturing operations; B. M. Bouman, problems pertaining to operators' chairs; C. W. McWilliams, quality survey on panel commutators; and H. O. Siegmund, C. G. McCormick and G. B. Baker, on matters pertaining to step-by-step relays.

* * * * *

Recent visitors from the Western Electric Company Plant at Hawthorne have included F. E. Henderson who discussed the manufacture of filled coils; C. A. Purdy, insulation problems; and W. B. Tall, finish problems.

Collegiate Degrees Awarded During 1939

J. C. Adams	B. Chem. E.	Cooper Union	J. J. McAleer	B.M.E.	Cooper Union
H. W. Allison	B.E.E.	Cooper Union	C. V. Obst	B.M.E.	Brooklyn Poly.
H. J. Berka	B.E.E.	C.C.N.Y.	A. C. Pfister	B.M.E.	Brooklyn Poly.
A. P. Besier	B.E.E.	New York Univ.	G. S. Phipps	M.S.	Columbia
R. R. Blair	M.A.	Columbia	C. M. Redding	B.S.	New York Univ.
J. H. Bollman	B.E.E.	Brooklyn Poly.	H. A. Sauer	M.S.	New York Univ.
A. A. Budde	B.M.E.	Cooper Union	W. E. Smith	B.E.E.	Brooklyn Poly.
E. B. Cave	LL.B.	New York Univ.	B. Stauss	B.E.E.	Cooper Union
F. K. Harvey	B.E.E.	New York Univ.	R. L. Taylor	M.A.	Columbia
			H. C. Theuerer	M.A.	Columbia

R. H. Wilson, who was recently appointed General Service Manager of the General Staff Department, completed a quarter century of service in the Western Electric Company and the Laboratories on the twenty-ninth of June. Mr. Wilson received the B.Sc. degree from Victoria University, Manchester, England, in 1913 and the M.Sc. degree in 1923. Upon graduation he came to Canada where he was an instructor in the University of Toronto. He joined the Engineering Department of the Western Electric Company in 1914 where he developed radio receiving equipment. He was intimately associated with the experimental radio work done between Montauk Point and Wilmington, Delaware, which culminated in the successful transatlantic tests between Arlington and Paris in 1915. For the next three years he designed and developed various types of vacuum tubes, particularly for war purposes.

Early in 1919 Mr. Wilson transferred to research service and a year later was placed in charge of this work where he remained until this May as Research Staff Engineer. In this position he was responsible for all service functions performed for the Research Department and his activities covered the supervision of special research design and drafting and the handling of laboratory, order and administrative services as well as departmental stores. A new method of stock-room control was introduced under his direction which has resulted in increased efficiency in service and reduction in cost of overall operation. In this connection he was the author of two articles, *A New Method of Stock Control* and *A Scientific Routine for Stock Control*, both published in the *Harvard Business Review* for January, 1927, and October, 1934, respectively.

As General Service Manager, Mr. Wilson is now in charge of transcription service, correspondence files, central stores, traffic, and office services such as mail, messenger, telegraph and photostat, photographic and blueprint facilities. He will also take over certain service functions which are now performed by local service organizations in each of the technical departments.

John R. Carson completed a quarter century of service in the Bell System on the first of July. He was graduated by Princeton University in 1907 with a B.S. degree and received the degrees of Electrical Engineer in 1909 and Master of Science in 1912. Following two years at Princeton as an instructor in physics and electrical engineering Dr. Carson, in 1914, joined the Engineering Department of the American Telephone and Telegraph Company and continued in the Department of Development and Research when this was formed in 1919. He was made Transmission Theory Engineer in 1924 and carried on the same general type of work in the Laboratories following the 1934 consolidation. In 1936 he became Research Mathematician in the Circuit Research Department.

Dr. Carson is the inventor of the single-sideband suppressed-carrier method of transmission, now widely used in wire and radio communication; for this and for his development of the theory of transients by means of the operational calculus he received the Morris Liebmann Prize of the Institute of Radio Engineers in 1924. The honorary degree of Doctor of Science was conferred on him in 1936 by Brooklyn Polytechnic Institute for his contributions to the theory of electrical transmission. He was awarded an Elliott Cresson Medal by The Franklin Institute of Philadelphia in 1939 "in consideration of outstanding contributions to the art of electrical communications." He holds over twenty-five patents relating to wire and radio transmission and is the author of about fifty scientific papers and of the book *Electric Circuit Theory and the Operational Calculus*.

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R. A. Heising has had a long record of achievement in radio during his twenty-five years of service in the Western Electric Company and the Laboratories which he completed on the twenty-seventh of July. After receiving the E.E. degree from the University of North Dakota in 1912 and the M.S. degree from the University of Wisconsin in 1914, he joined the Research Department of the Western Electric Company

and participated in the long-distance radio-telephone experiments of 1915. He developed and operated the transmitting sets for the Montauk-to-Wilmington experiments and for those from Arlington to Paris, San Francisco and Honolulu.

During the war he was a member of the Sub-committee on Wireless Communication between Aircraft of the National Research Council. Many of his investigations at this time were with radio telephony for airplanes, sub-chasers, and other military units. In addition he devoted some time to training technical men detailed to the Laboratories by the War Department. After the war he took part in the development of the ship-to-shore radio telephone, and later in the development of the long-wave transatlantic radio-telephone circuit. For the past several years Mr. Heising, as Radio Research Engineer, has had charge of numerous fundamental investigations in ultra-short-wave and piezo-electric phenomena.

Mr. Heising has published many technical and scientific articles in the *Journal of the I.R.E.*, the *Journal of the A.I.E.E.*, and in the *Physical Review*, and has nearly 115 patents to his credit with others pending. In 1921 he was awarded the Morris Liebmann Memorial Prize by the Institute of Radio Engineers. He has been very active in the affairs of the Institute and is at present its President.

R. H. Wilson

ON THE EIGHTH OF JUNE, H. C. Harrison completed twenty-five years of service with the Western Electric Company and the Laboratories. After receiving his A.B. degree from Colorado College in 1910, Mr. Harrison came to the Massachusetts Institute of Technology from which he received the S.B. degree in 1913. He remained with the Institute for a year as an instructor and then joined the Engineering Department of the Western Electric Company. In the Transmission Laboratory, he first engaged in fundamental studies of receivers and carbon-button microphones. He then worked on receivers and loud speakers for public address systems and the development of sound-recording and reproducing methods that resulted in the Orthophonic and disk-type sound-picture systems.

Following this the vertical or "hill and dale" system of sound recording and reproducing was developed by Mr. Harrison and the group directly under his supervision. He was instrumental in applying the principles of electric transmission theory to sound-recording and reproducing equipment. These concepts proved revolutionary in the development of electro-acoustical systems. Among the things having important use growing out of this work were the rubber line recorders, electrical reproducers, and electro-acoustic sound systems matched in impedance from the electrical line through

John R. Carson

R. A. Heising

H. C. Harrison

the receiver and logarithmic horn to air as well as the mechanical Orthophonic sound system. Since June, 1937, he has been in the relay group of the Circuit Research Department where he is responsible for the investigations of new types of ringers, relays and switches. Mr. Harrison's many important contributions to the communication art are attested to by the eighty United States patents issued in his name which cover microphones, recorders, reproducers, loud speakers, the Orthophonic phonograph, sound-measuring instruments and relays.

* * * * *

AT THE PRINCETON MEETING of the American Physical Society held on June 23 and 24, papers were read by L. H. Germer and F. E. Haworth, *Order in the Copper-Gold Alloy System;* by W. Shockley, *The Relationship Between Surface States and Energy Bands in Crystals;* and by H. E. Ives, *Theory of the Double Fizeau Toothed Wheel.* Others attending included W. H. Brattain, A. J. Ahearn, W. P. Mason and A. L. Johnsrud.

R. M. BURNS attended a meeting of the American Coördinating Committee on Corrosion which was held in Philadelphia.

H. W. DUDLEY, assisted by C. W. Vadersen, demonstrated the Vocoder before the Pacific Coast section of the Society of Motion Picture Engineers at a meeting held in Hollywood on June 27. The Vocoder, or voice analyzer-synthesizer, is the parent of the Voder, which is on demonstration at both the New York and San Francisco Fairs. Speech currents are instantaneously analyzed as to pitch and as to frequency bands and their intensities. This information, transmitted in the form of several low-frequency currents to the synthesizer, controls its operation in re-creating the speech. By manipulation of the control currents interesting variations can be made in the speech characteristics.

THE POUGHKEEPSIE TOLL OFFICE was visited by D. R. Brobst, G. H. Downes and H. E. Marting for the purpose of examining the local cables and selecting one from those installed in 1925 on which various tests are to be made in the Laboratories.

AT CHICAGO and FORT WAYNE, A. E. Petrie, V. T. Callahan and J. H. Sole coördinated the application of charging machines of one manufacturer with engine sets made by a different manufacturer.

E. J. KANE discussed crossbar equipment with engineers at Lynn, Massachusetts.

E. K. EBERHART visited Washington to inspect The Chesapeake and Potomac Telephone Company's installations of daylight fluorescent lighting in large rooms and at distributing frames.

W. W. BROWN discussed service-observing problems while in Cleveland.

D. E. TRUCKSESS and R. P. JUTSON made noise tests at Philadelphia.

C. H. ACHENBACH discussed small power plants at Pittsburgh, Cleveland and Hawthorne.

F. K. Low was in Cincinnati in connection with panel maintenance problems.

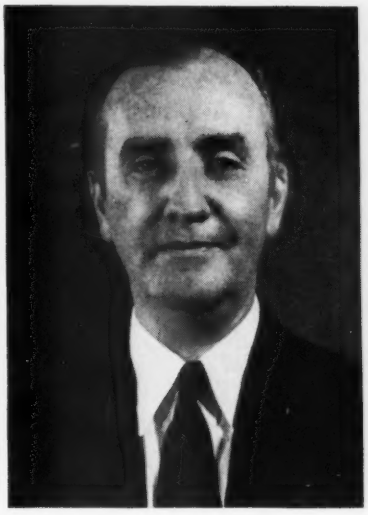
A. E. BACHELET spent two days at Glens Falls, New York, observing the operation of cable-program circuits.

R. W. CHESNUT and M. L. ALMQUIST, accompanied by F. MacMillan and W. A. Olson of the Long Lines, observed the type-J2 carrier-telephone system which is now undergoing trial on an open-wire line between Dallas and San Antonio. They also stopped at Oklahoma City to examine the commercial J1 system operating between that point and White Water, California. At St. Louis they saw several engineers of the Southwestern Bell Telephone Company with whom they discussed carrier-telephone problems.

MEMBERS OF THE LABORATORIES ENROLLED IN THE TELEPHONE PIONEERS OF AMERICA DURING THE FIRST HALF OF 1939

Barber, C. C.
Bender, H. D.
Betzner, I. S.
Bryson, James
Buhler, William
Cioffi, P. P.
Clapp, R. H.
Cleary, Miss K. H.
Coyne, H. L.
Craig, Miss H. M.
Cramer, H. C.
Davisson, C. J.
Doscher, P. A.
Eckerson, A. G.
Ellis, M. E.
Enger, H. S.
Findley, P. B.
Glezen, L. L.
Goddard, M. C.
Grant, T. B.
Habermehl, L. D.
Haynes, C. H.
Helbing, E. F.
Held, William, Jr.
Hobbs, Alan
Jentschke, Miss Louise
Johlfs, J. F.
Johnston, Miss M. E.
Josberger, Frank
Klarmann, Miss E. A.
Kearns, J. F.
Kelly, M. J.
Kuch, F. C.
Leuvelink, Bernard
Marshall, Miss A. K.
Maxey, J. M.
Mazzi, T. J.
McConnell, C. R.
Melick, J. M.
Mezger, Fred
Millard, A. C.
Muldoon, William, Jr.
Osten-Sacken, I. C.
Reeve, H. T.
Sauer, Jacob
Saunders, A. R.
Sause, E. J.
Schelleng, J. C.
Shangle, A. H.
Smith, G. O.
Smith, W. D.
Subrizi, Victor
Thorn, J. B.
Viggers, Miss E. A.
Waldman, Frank

E. C. Taylor



F. J. Boyle

C. G. Von Zastrow

RECENTLY, R. W. Harper, F. R. Lamberty, W. H. Scheer and H. E. Marting were at Jonesville, New York, in connection with the initial installation of the 380A dial office equipment which is a new small community office using crossbar switches.

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A FIVE-STAR SERVICE EMBLEM signifying the completion of twenty-five years of service in the Western Electric Company and the Laboratories was awarded to E. C. Taylor on the twenty-ninth of June. Mr. Taylor joined the Engineering Department of the Western Electric Company in 1914 during the time when the semi-mechanical dial system, installed at central offices in Newark, was being developed. For several years he was engaged in the drafting work involved in the apparatus phases of this development. He also was concerned with the design of spiral gears and friction-roll drives for panel systems. Since then, in the drafting group of the Apparatus Development Department, he has been associated with the mechanical design of testing equipment and telephone apparatus. He has also assisted in the design of much of the apparatus used in the special laboratory for precision linear measurements.

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F. J. BOYLE joined the Voucher Division of the New York Distributing Department of the Western Electric Company at West Street early in 1913 and just before the World War moved with them to 151 Fifth Avenue. Mr. Boyle left the company in 1918 and spent ten months in France with the 52nd Pioneer Infantry of the First Army Corps. Upon his return he continued with his former work in the Distributing Department but left a few months later to become a bookkeeper with the George Weiderman Electrical Company in Brooklyn.

In December, 1920, Mr. Boyle came back to the Bell System as a buyer of hardware materials in the Purchasing Department of the Laboratories, then the Engineering Department of the Western Electric Company. About a year and a half later he transferred to the Financial Department as a paymaster and later as a teller, remaining in this department for thirteen years. Since April, 1935, he has been assigned to duties with the expense accounting group of the General Accounting Department. On the twenty-ninth of June Mr. Boyle received a five-star emblem signifying his completion of twenty-five years of service in the Bell System.

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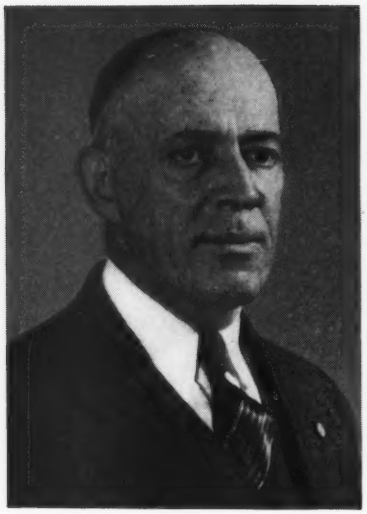
ON THE TWENTY-SIXTH of June, C. G. Von Zastrow of the Systems Development Department completed twenty-five years of service in the Bell System. Mr. Von Zastrow joined the Installation Department of the Western Electric Company in 1914 where, in the Philadelphia district, he was engaged in the installation of manual equipment. A year later he came to the toll group of the Western Electric Engineering Department at New York and worked on a trial installation between Philadelphia and Baltimore where a multiplex telegraph distributor was used for call-circuit toll line signaling. In July, 1917, he joined the Research and Inspection Division of the U. S. Army and spent eighteen months in France as an inspector of Signal Corps equipment.

Upon his return to West Street Mr. Von Zastrow continued in the toll development group where he took part in the trial installation of two-way telephone repeaters with passive impedance between Davenport, Iowa, and San



A. C. Satter

H. L. Lundberg

Francisco. Following this he spent about two years in the method of operations group and then returned to the toll group where he was engaged in laboratory testing and analyzation of Western Electric orders. Since 1937 Mr. Von Zastrow has been associated with the circuit standardization group where he is a specialist in toll-circuit drawing practices and toll-circuit key sheets.

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A SHORT TIME AGO, C. W. Schramm, D. B. Penick, R. S. Caruthers, H. A. Wenk and C. W. Lund returned from the trial installation of the type-J2 carrier-telephone system between Dallas and San Antonio.

C. S. YEUTTER returned recently from Toledo where he has been observing the trial installation of the automatic pilot channel deviation regulator for the type-K carrier-telephone system.

F. B. ANDERSON has been at Washington, Richmond and Baltimore studying the performance of the type-K regulation circuits.

AT WASHINGTON, E. F. Watson, E. L. Nelson and D. K. Martin witnessed demonstrations of the operation of a teletypewriter in an airplane conducted under the auspices of the Civil Aeronautics Authority. They also attended a meeting of the ultra-high-frequency subcommittee of the Radio Technical Committee for Aeronautics.

M. R. PURVIS with representatives of the Long Lines Department was in Chicago from June 19 to 24 to investigate magnetic interference in polar relays in telegraph circuits.

AN ARTICLE ENTITLED *High Definition Television* by Pierre Mertz was published in the July issue of the *Journal of Applied Physics*.

R. L. KAYLOR made tests of radio induction in various towns throughout New England. For part of the tests he was joined by R. A. Shetzline.

R. L. TAYLOR presented a paper, *Wave Shape of 30- and 60-Phase Rectifier Groups*, prepared jointly with O. K. Marti of Allis-Chalmers Manufacturing Company, at the Summer Convention of the A.I.E.E. in San Francisco. While in California, Mr. Taylor discussed problems relating to noise coördination with various engineers of The Pacific Telephone and Telegraph Company.

AT PHOENIXVILLE, E. F. Vaage, R. W. Marshall, H. W. Herrington and L. F. Staehler have been carrying on an extensive series of tests to determine the possibilities of broad-band operation on special arrangements of open-wire pairs.

E. S. WILCOX has been in Temple, Texas, for some special crosstalk tests as a part of the Laboratories trial of the J2 carrier system between Dallas and San Antonio.

J. H. SHUHART, in Eau Gallie, Florida, and C. H. Gorman, Jr., in Daytona Beach, made crosstalk tests at J-system frequencies on the St. Augustine-West Palm Beach open-wire line.

R. M. HAWEKOTTE took part in a coöperative field study of an inductive coördination problem in the vicinity of Morristown, involving telephone circuits of the New Jersey Bell Telephone Company. He was accompanied by L. B. Bogan of the A. T. & T. and H. W. Wahlquist of the Edison Electric Institute.

IN TEXAS and NEW MEXICO, M. T. Dow, J. L. Lindner, W. E. Reid and Miss E. Rentrop have completed an extended series of tests to obtain information on the extreme levels of dust static noise in open-wire circuits and on the control of its effects by draining the circuits in various ways. The tests were made during the peak of the dust-storm season. The measurements were made in the voice-frequency and the C and J carrier-frequency range on circuits of the Trinidad-Amarillo line and the Fourth Transcontinental Line.

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A. C. SATTER joined the Manufacturing Department of the Western Electric Company at West Street in 1910 where he assembled relay selector sets. When the manufacturing group moved to Hawthorne, Mr. Satter transferred to the Installation Department at Brooklyn. Shortly thereafter he left the company and became a supervisor in the Inspection Department

of the Johns-Manville Corporation. In September, 1917, he returned to the Western Electric Company and, in the Tube Shop, was given the responsibility of maintaining all vacuum pumps, including those in other departments throughout the building, which totalled about two hundred sets.

Following the war he transferred to the building service group of the Plant Department where, in addition to maintaining vacuum pumps, he assisted in the construction of power panels, life test racks and other equipment. From 1932 to 1934 he was in the Development Shop on bench assembly and general mechanical work but still retained vacuum pump maintenance. He then transferred to the Research Department with the development group engaged in the processing of vertical-cut records. Since the end of 1937 he has been in the Commercial Products Development Department on similar work and on the maintenance of phonograph recorders. On the fifth of June, Mr. Satter was awarded a five-star emblem signifying his completion of twenty-five years of service in the Bell System.

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H. L. LUNDBERG, who completed a quarter century of service in the Western Electric Company and the Laboratories on the twenty-sixth of June, joined the Library of the Engineering Department in 1914. Two years later he transferred to the Research Department where for several years he was engaged in the maintenance of standards. He then joined the telephone instruments group of the Transmission Engineering Department where he was concerned with the design and construction of equipment used in testing transmission instruments and made studies to determine the advisability of using new materials and improved manufacturing processes in the manufacture of the instruments. During the war Mr. Lundberg was concerned with the development of submarine detection devices for the U. S. Navy and, when the war closed, returned to his work in the telephone instruments group. He worked on broadcast microphones, and the first carbon microphone used by Radio Station WEAF passed through his hands. He also assisted with the development of the microphones used on President Harding's tour of the country.

Later Mr. Lundberg became associated with the development of instruments for ground-station use with aircraft radio systems. During this time he contributed to the development of the lapel microphone which has since been widely used. Since 1932 he has been concerned with the current-engineering phases of audiphone development, first in connection with the 36-, 37-, and 38-types and more recently with the Orthotechnic type, particularly with the latter's 111A mechanical amplifier.

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A FIVE-STAR SERVICE BUTTON, emblematic of twenty-five years of service in the Western Electric Company and the Laboratories, was conferred on Rodger Clifford on the sixth of July. He joined the Western Electric Company in 1914 and for the next twelve years served as a porter in the Plant Operation Department. Since then he has been a uniformed watchman and elevator operator serving on various doors and elevators.

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A. N. JEFFRIES' first contact with the Bell System was during a summer vacation in 1911 when he worked in the Plant Department of the Cumberland Telephone and Telegraph Company at Jefferson City, Tennessee. In 1914 he was graduated from the University of Tennessee with the degree of B.S. in Electrical Engineering, and immediately joined the student course of the Western Electric Company at Hawthorne. Following the usual shop training and installation experience at Omaha, Des Moines, St. Paul and Minneapolis, he entered the Hawthorne section of the Apparatus Development Department where he spent one year in the development of miscellaneous central office apparatus and one year on repeating and loading coils. In 1917 he

Rodger Clifford

A. N. Jeffries

came to New York where he continued his work on the design and development of loading coils.

A year later Mr. Jeffries transferred to the division engineer's office of the Northwestern Bell Telephone Company at Minneapolis on equipment engineering. Early in 1920 he entered the Engineering Inspection Department at Hawthorne. When this department was reorganized in 1924, he returned to West Street where he dealt first with investigations of complaints on special apparatus and later became head of the Complaint Bureau. More recently he has been in charge of a group handling central office complaints and quality engineering. Mr. Jeffries completed twenty-five years of service in the Bell System on the twenty-fourth of June.

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A. J. AIKENS has been making crosstalk tests at the type-J auxiliary repeater station in Winnsboro, South Carolina. C. W. Lund, W. R. Steeneck and R. S. Tucker visited the station in connection with this work.

TOLL-LINE DIALING between Akron and Columbus was discussed by D. L. Moody, R. A. Shetzline and E. R. Taylor with engineers of The Ohio Bell Telephone Company at Cleveland.

D. K. GANNETT delivered a paper on the new volume indicator and volume standards before a joint meeting of the A.I.E.E. and I.R.E. in San Francisco on June 29.

NEAR FORKED RIVER, NEW JERSEY, H. A. Affel, E. I. Green, L. G. Abraham and J. T. Dixon observed the installation, by plowing, of a new thin-sheathed rubber-covered toll cable.

AT NORWICH and NEW LONDON, P. G. Edwards, R. D. Fracassi and H. Baillard watched the first experimental installation of thermistors for temperature compensation in voice-frequency, two-wire, loaded-cable circuits.

C. E. CLUTTS returned from a six-week trip to Texas in connection with the trial installation of the type-J2 carrier system.

TESTS OF AMPLIFIER switching arrangements for type-J carrier-telephone systems were made by H. G. Jordan, L. C. Roberts and H. A. Wenk at Dallas and Milford, Texas.

H. R. NEIN has been at Austin and San Antonio participating in tests on the type-J2 carrier-telephone system.

AT MINNEAPOLIS, J. Mallett, G. B. Engelhardt and H. W. Evans have been carrying out tests on the initial section of the coaxial cable between Stevens Point and Minneapolis.

ON JUNE 15, H. E. Crosby, R. L. Young, L. E. Coon, A. G. Jensen and P. Mertz attended the monthly meeting of the Metropolitan Chapter of the American Society of Safety Engineers.

E. C. WALSMAN visited the General Fireproofing Company at Youngstown, the Steel Storage Company and Nela Park Institute at Cleveland, the Art Metal Construction Company at Jamestown, the Remington Rand Company at Tonawanda and the Yawman and Erbe Company at Rochester with J. J. Murphy of the A. T. & T., and E. B. Gage and C. S. Johnson of the Western Electric in the interests of the Western Electric Office Equipment Standardization Committee. The purpose of the trip was to observe steel furniture manufacturing processes, particularly as regards color finishing.

MEMBERS OF THE LABORATORIES TO WHOM PATENTS WERE ISSUED DURING THE MONTHS OF APRIL AND MAY

L. G. Abraham
F. B. Anderson
A. E. Bachelet (2)
H. M. Bascom
E. H. Bedell
H. H. Benning
C. A. Bieling
W. M. Bishop
H. S. Black
F. E. Blount
R. W. Chesnut
K. G. Coutlee
G. C. Cummings
S. Darlington
P. S. Darnell
J. W. Dehn
A. C. Dickieson
S. Doba, Jr. (2)
A. D. Dowd
W. C. Ellis
W. A. Evans
E. B. Ferrell
H. J. Fisher (2)
K. E. Fitch
J. J. Gilbert
J. H. Gray
A. F. Grenell
R. B. Hearn
R. A. Heising (2)
S. C. Hight
W. H. T. Holden
O. M. Hovgaard
J. B. Johnson
R. P. Jutson
W. F. Kannenberg
R. J. Kent
K. L. King
F. S. Kinkead (2)
C. S. Knowlton
L. F. Koerner
M. E. Krom
F. A. Kuntz
J. P. Laico
J. L. Larew
V. E. Legg
C. A. Lovell
R. F. Massonneau
F. H. McIntosh
H. E. Mendenhall
R. L. Miller (3)
D. Mitchell
J. F. Morrison
W. E. Mougey
O. Myers
N. D. Newby
N. C. Norman
J. R. Pierce
G. Rodwin
V. L. Ronci (2)
G. N. Saul
S. A. Schelkunoff
L. Schott
L. J. Sivian
G. C. Southworth
N. E. Sowers
L. K. Swart
G. K. Teal (4)
D. E. Trucksess
H. E. Vaughan
E. Vroom
E. F. Watson
M. A. Weaver
E. C. Wente
W. W. Werring
J. W. West
C. H. Wheeler

Portable High-Frequency Transmission-Measuring Set

By F. R. DICKINSON
Toll Equipment Development

ONE of the essential requirements for the development and maintenance of long-distance lines is the provision of means for accurately measuring gains or losses in the component parts of the system. Transmission-measuring sets, as a result, have been made available to meet a variety of requirements. Until recently, however, the highest frequency employed has been about thirty kilocycles, used for the type-C carrier system. Transmission-measuring sets for these high frequencies have been of the bay-mounted type, and are permanently installed in terminal offices or in major repeater stations.

With the advent of the J and K carrier systems, it was necessary to design a new set because of the much higher range of frequencies to be measured—running up to 150 kc—and of the higher gains and losses involved. Moreover, the use of many additional small repeater stations, most of them maintained from main stations, made it desirable to make a portable set. As a result, the 30A transmission-measuring set has been developed. It is housed in a cabinet approximately twenty by twelve by six and one-half inches, and its total weight is only thirty-six pounds.

The general method of measurement is indicated in Figure 1. An external oscillator—the 17B* has been provided for the purpose—serves as a source of testing current; and a sensitive microammeter, connected across a thermocouple, acts as the indicating device. The set provides two paths between the oscillator and meter, in one of which are two adjustable attenuators, giving adjustment in 1-db steps from 0 to 60 db, and a fixed attenuator of 30 db. Either path may be selected by means of the "adjust-compare" key. When a unit having an unknown overall loss is to be measured, it is plugged into the jacks in the lower path. The loss in the attenuator is then adjusted to equal the unknown loss, comparative readings being taken through each branch of the set until the meter readings are the same.

*RECORD, *May*, 1939, *p.* 291.

When a unit having an overall gain is to be measured, it is inserted in the upper path at the output of the attenuator. Again, adjustments are made in the attenuator until the meter readings through both branches of the circuit are the same, which indicates that the net loss through the upper branch is zero. The unknown gain is then equal to the attenuator reading. Since the smallest unit of attenuator adjustment is 1 db, fractional parts of a db are read on the meter scale, which is marked in heavy lines over the range from −1 to +1 db. The 0-db reading in the center of the scale corresponds to one milliwatt, which is the reference level of the set. At this point the accuracy of the meter is one-quarter of one per cent.

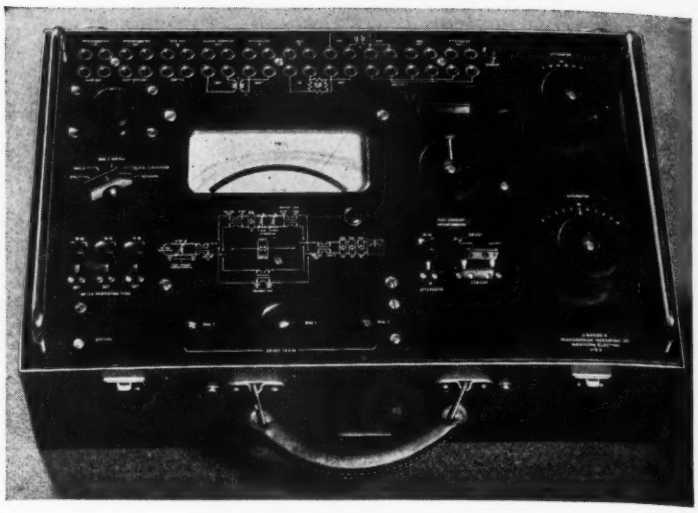


Fig. 2—Top view of test set with cover removed

Since the meter is of the thermocouple type, it may be calibrated on direct current, and a flashlight cell is included in the set for this purpose. The complete calibration is accomplished in three steps, using the five-position switch at the left center of the test set, shown in Figure 2. The switch is first turned to the position marked "dial 1," which establishes a circuit as shown in the upper part of Figure 3. The battery is connected across a high-resistance potentiometer, controlled by "dial 1," and across the potentiometer is connected a 135-ohm resistance through an ammeter shunt. Since the high-frequency carrier systems are designed for 135-ohm circuits, the test set is similarly designed, and is calibrated as a termination for circuits of this impedance. "Dial 1" is adjusted until the meter reads zero.

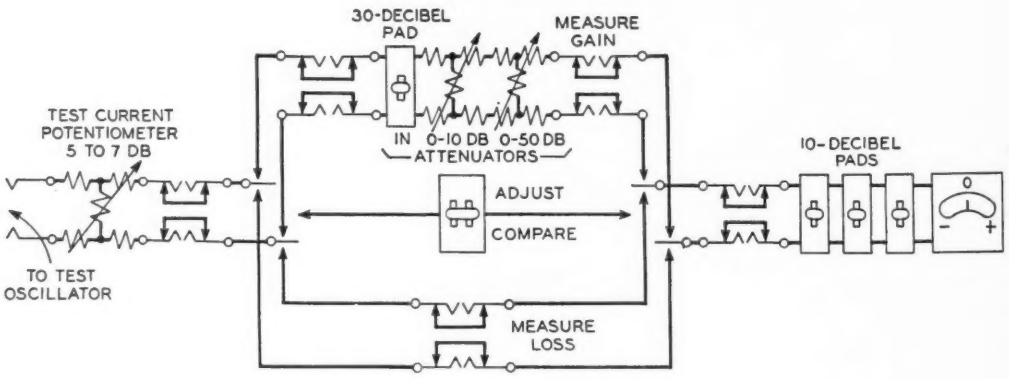


Fig. 1—Simplified schematic of the 30A transmission-measuring set

When connected to the shunt in this manner the meter will read zero with a current of 2.72 milliamperes, which is the current that is required for one milliwatt of power in the 135-ohm resistance.

Having thus adjusted the battery current to give an output of one milliwatt into a 135-ohm resistance, the switch is turned to the position marked "dial 2," which gives the connections shown in the middle of Figure 3. In this position, the 135-ohm resistance is replaced by the thermocouple in series with the resistance controlled by "dial 2," which is adjusted until the meter pointer again rests at the zero position. This adjusts the resistance of the thermocouple circuit to 135 ohms.

With this adjustment made, the switch is turned to "dial 3" position, which gives the connections shown in the lower diagram of Figure 3. This is the same as for the previous arrangement, except that the meter has been moved from the shunt to the thermocouple. "Dial 3" is adjusted until the meter pointer is again at zero. The thermocouple may give slightly different readings depending on the direction of current through them, and a fourth position is provided on the switch to reverse the current to the thermocouple. "Dial 3" is adjusted so that the meter gives equal deflections on both sides of the zero for the two directions of current flow. The thermocouple is in a separate replaceable unit, mounted just above the calibration switch, and, for extremely precise results, various thermocouples may be tried until one is found that has little or no directional effect. When this final step of the calibration is completed, the switch is turned to the fifth position, which disconnects the battery and connects the set so that it is ready for making measurements.

Although designed for measurements on 135-ohm circuits, the set may be used on 600-ohm circuits by inserting repeating coils, which are incorporated in the set. These introduce some loss, for which a correction must be made when precise measurements are desired. The correction per coil is less than ½ db over the frequency range from 100 to 150,000 cycles. A 10-db loss network is also provided for use when the 90 db provided for normal use is not sufficient. This network and the two repeating coils are connected to jacks along the upper part of the set, so that they may be patched into the circuit at any of the five jack positions indicated in Figure 1, these jacks also being mounted in the row along the

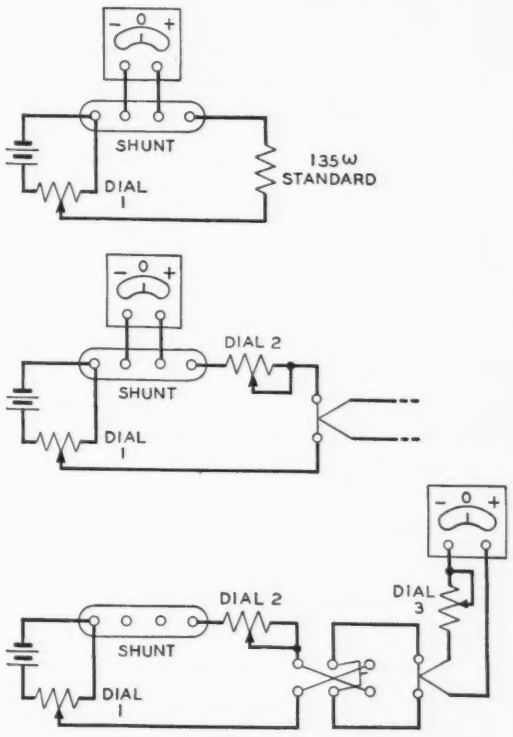


Fig. 3—Calibration of the 30A test set is accomplished in three steps shown in order above from top to bottom

top of the set. A set of three pairs of jacks is also provided, connected in parallel, which may be used when multiple connections are required. Three 10-db pads, controlled by keys at the lower left corner of the set, are provided in series with the meter to prevent damage from large current during the early stages of a measurement. These may be cut out, one at a time, by the keys and are all out for the final measurement.

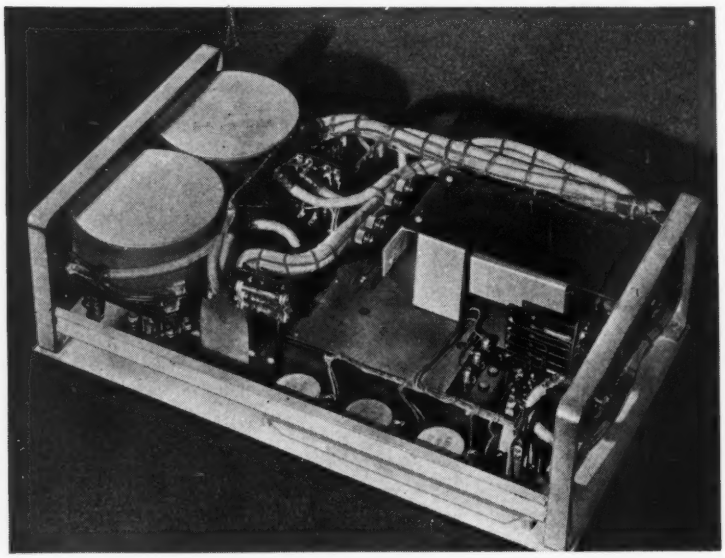


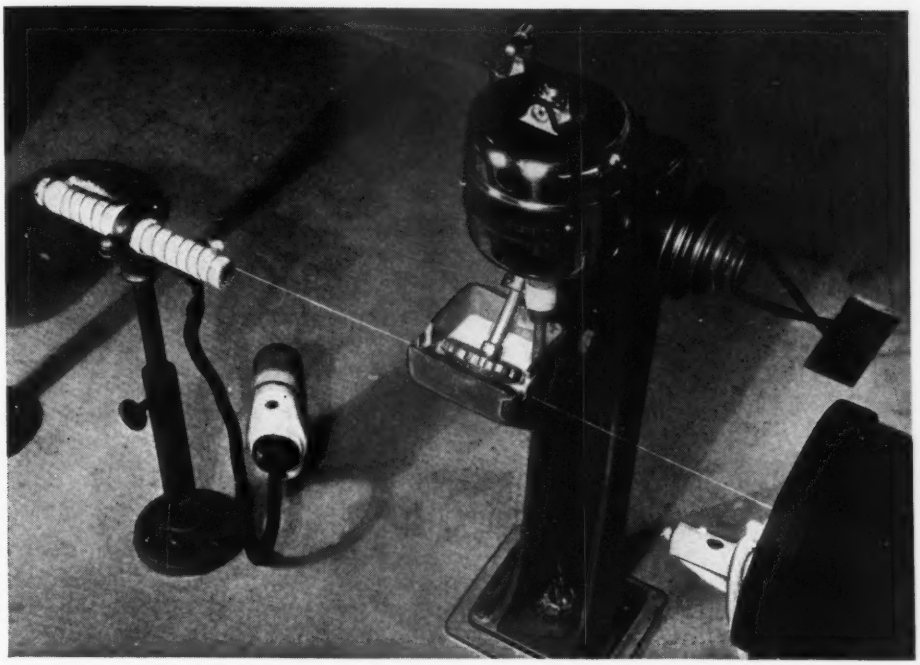
Fig. 4—Under side of the 30A test set when removed from case

Because of the high frequencies for which the set will be used, and the wide range in level, careful consideration had to be given to all parts of the design. All the keys except the adjust-compare key have twin contacts to increase their reliability. Side-wiping contacts are provided for the adjust-compare key for a similar reason. The attenuators all have silver wiping-contacts with non-inductive resistances and are accurate within 0.1 db. Internal shielding of the component parts is of prime importance. The row of jacks at the top of set is shielded by a structure resembling the ice tray of an electric refrigerator, each pair of jacks being in one compartment. Within the row, the jacks are located so as to bring high differences in level as far apart as possible. The attenuators all have their overall shields, with separate shields for the resistances. The two halves of the "adjust-compare" key, where high differences of level occur, are completely boxed in by shields, and the operated position of the key that cuts in the 30-db attenuator is completely enclosed. Rubber-covered shielded wire is used to reduce crosstalk and capacity to ground. The two repeating coils have been placed at right angles to each other to reduce crosstalk effects observed when the coils are parallel. The metal top panel, when grounded, serves as a shield for the entire set, and all the jack sleeves are grounded through contact with it.

This top panel serves also as a mounting plate for all the apparatus, and is arranged for removal from the casing as shown in Figure 4. A cover, not shown in the photographs, protects the top of the set when not in use or during shipment. This cover, when in place, depresses a button just below the right-hand corner of the meter, which operates a short-circuiting switch on the moving coil of the meter to damp the movement and lessen the likelihood of damage when the instrument is in transit. The top panel is of heavy aluminum sheet, which is treated by a patented proc-

ess known as alumiliting. This process, which includes a black aniline dye for color, gives the panel an aluminum oxide coating of sapphire hardness and extreme resistance to wear, with an appearance similar to that of phenol fibre. By means of a printing process from a photographically produced master plate, the name-plate, designations, and diagrams are etched through the oxidized surface to the bright aluminum beneath. With such a process, the number of designations placed on the plate has practically no effect on the cost, and it was therefore found desirable to include a simplified schematic diagram in the space below the meter. The designations on the apparatus together with the simplified schematic diagram make the set practically self-instructing. With only a limited knowledge of its operation a person wishing to make transmission measurements is able, in a very short time, to realize its full capabilities and be able to make any desired measurement.

Use in the field has proved this 30A transmission-measuring set a valuable unit of testing equipment. Its compact size and light weight make it convenient, and its high accuracy yields results equivalent to those ordinarily obtained in the laboratory.



Apparatus developed by the Laboratories to coat vacuum-tube filaments automatically. The fine core-wire passes through coating baths and then through electric furnaces to dry the coating. The slotted wheel applies the coating mixture as it passes along a groove in the wheel. The mixture is stirred by a small motor-driven propeller

Simplifying the Adjustment of Antenna Arrays

By J. F. MORRISON
Radio Broadcast Development

IN RECENT years radio broadcasters have been extensively utilizing multiple-element antenna systems to make the most effective use of their licensed power. These antenna arrays, usually consisting of two or more vertical antennas, allow a directional control of the radiated power, thus permitting a reduction in interference with stations operating on the same or on an adjacent frequency and an increase in signal strength in densely populated areas where high noise conditions generally prevail. Two examples of such arrays have already been described in the RECORD.*

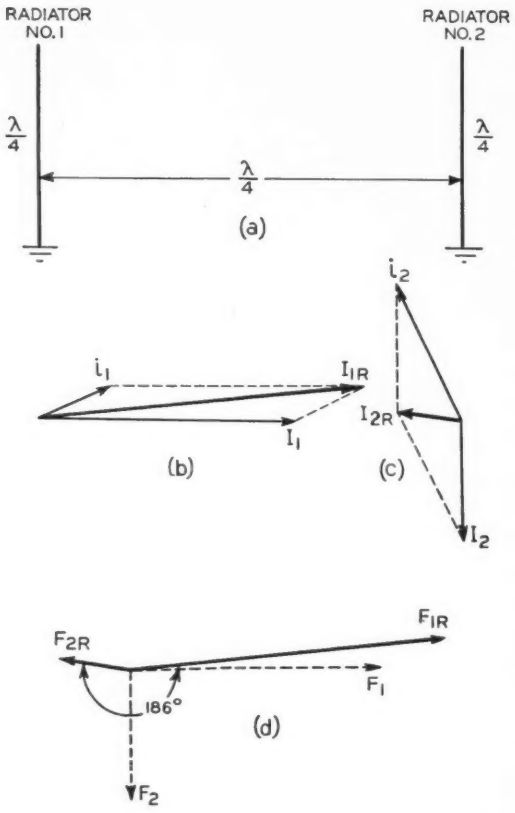


Fig. 1—Because of currents induced in each radiator by currents in the other, the resultant currents in each of the radiators differ considerably from those that would exist without the mutual effect

The radiation patterns obtained from such arrays depend upon the separation of the individual towers generally used for antennas, and on the relative magnitude and phase of the current in each of them. Once the desired radiation pattern has been agreed upon, and the spacing of the antennas settled, it is possible to calculate what the relative magnitude and phase of the current in each antenna should be. To secure these desired currents, however, is not simple. Line-branching and phase-shifting networks are provided to control the magnitude and phase of the current to each antenna, but how these networks should be adjusted to give the desired antenna currents cannot be predicted in advance because of the reaction of the current in each antenna on the current in the others.

Assume, for example, that two quarter-wavelength antennas spaced a quarter wavelength apart were to be employed to secure a particular pattern, and that the current in radiator 1 was required to be twice the magni-

*RECORD, *April*, 1935, *p.* 232, and *September*, 1936, *p.* 17.

tude of that in radiator 2 and to lead it by 90 degrees. If the current in one radiator had no effect on that in the other, all that would be required would be to adjust line-branching and phase-adjusting networks so that the current flowing to radiator 1 would be twice that going to radiator 2 and would lead it by 90 degrees. The radiated fields from the two antennas are proportional to the respective currents, and the field in any direction would be the resultant of these two component fields, allowing for the phase difference caused by the quarter-wavelength separation of the two antennas.

Actually, however, the current in each radiator induces a current in the other, with the result that the net current in each is the vector sum of the current fed to the antenna from the transmitter and that induced in it by the current in the other radiator. The effect of this is shown vectorially in "b" and "c" of Figure 1, where 1 is the current supplied to the radiators from the transmitter, and i is the current induced in the radiator by the current in the adjacent radiator. In the diagram, subscripts 1 and 2 are employed to differentiate the currents in the two radiators. The resultant currents I_r are then a first approximation of the actual currents in the radiators.

The two radiated fields are in phase with the resultant current and are indicated at (d) on the diagram. The desired fields are indicated by the dotted vectors, and the wide divergence of the actual values—resulting from the induced currents in the radiators—is plainly evident. The effect of the induced currents on the resultant currents in the antenna as shown on Figure 1 indicates why the line-branching and phase-shifting networks cannot be set to produce the desired difference between the currents in the two radiators.

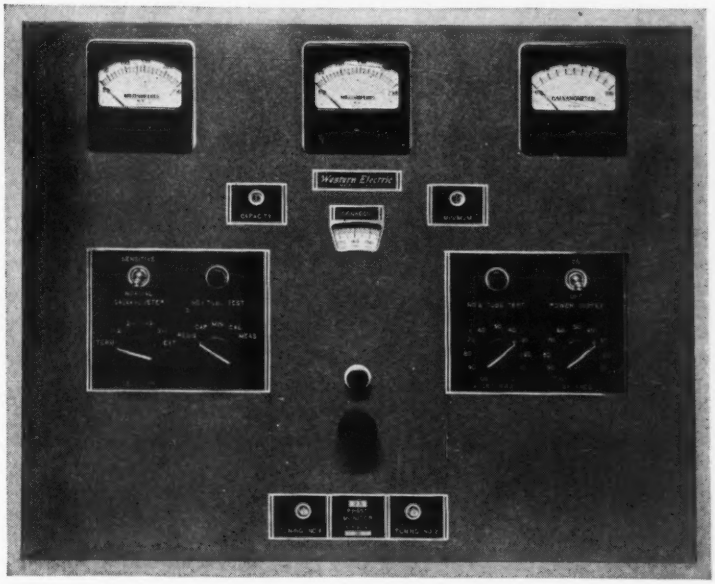


Fig. 2—The measuring apparatus is arranged on a 19-inch panel, which may be mounted on a relay rack if desired

To obtain the currents to give the desired pattern it has been necessary in practice to make an approximate adjustment and then to make field intensity measurements around the array. From these measurements, the magnitude and phase of the current in the radiators can be calculated, and changes can then be made in the networks to produce more nearly the desired results. This process might have to be repeated a number of times, with the result that the adjustment of an array becomes a com-

paratively long and tedious process. Moreover the radiation pattern needs checking from time to time since the currents in the antennas may change because of variations in circuit characteristics. Thus it can be seen that some simpler means of determining the currents in the antennas of an array is highly desirable.

The 2A phase monitor has been developed to facilitate these original adjustments and to enable the station operator to restore or check them at any time. It consists of a panel, shown in Figure 2, connected to sampling loops on each tower by coaxial transmission lines as shown in Figure 3. The sampling loops consist of a single turn loop which is fastened to each antenna at a point sufficiently high above the ground to assure an accurate sample of the current flowing in the antenna. The dimensions of the loop as well as its points of attachment must be identical for both the antennas. The top of the loop is directly connected to the towers, while the bottom is insulated, and is connected to the center conductor of a coaxial line leading to the measuring equipment. The two transmission lines are made to have identical overall characteristics.

At the measuring equipment the lines are connected through radio-frequency thermal milliammeters, which indicate the magnitude of the two currents supplied to the input of a vacuum-tube galvanometer or voltmeter. Between the milliammeter M2 and the galvanometer on one of the lines, however, is a phase-shifting network which permits the phase of the current in that circuit to be shifted until it is the same as that supplied by the other line. The circuit is arranged so that when this condition is reached, the galvanometer will give a minimum reading, and the amount of phase shift required to bring the two currents into phase is indicated by the dial controlling the phase-shifting network. Since the magnitude and phase of the currents required to give the desired field distribution pattern are known, it is necessary only to adjust the line-branching and phase-shifting networks in the main

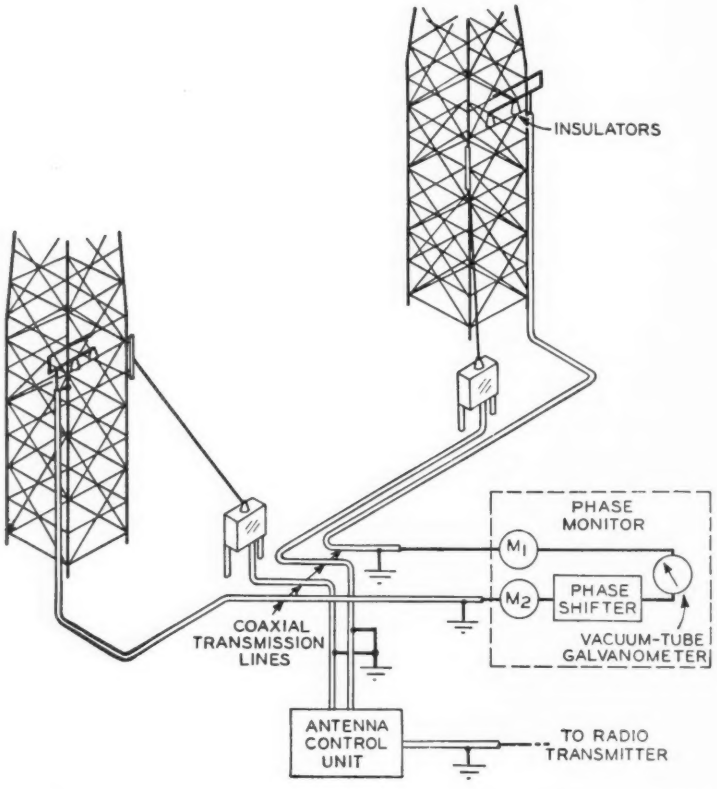


Fig. 3—Block schematic of method of directly measuring antenna currents by means of 2A phase monitor

lines to the antenna until those known values are indicated on the measuring equipment. The necessity of tedious field-strength measurements are thus unnecessary except as a final check.

The circuit of the measuring equipment is shown in schematic form in Figure 4. One of the coaxial transmission lines is connected through a radio-frequency milliammeter M2, a resistance R1, an inductance L1, and a capacity C5 to ground, the inductance and capacity each having impedances, at the carrier frequency, numerically equal to resistance R1, the characteristic impedance of the coaxial sampling line. Two identical high-impedance radio-frequency transformers with permalloy-dust cores, T1 and T2, are connected from the resistance to the ground and from the capacity to ground respectively, and thus produce on their secondary sides two potentials in quadrature with each other. The secondaries of these two transformers are grounded at their midpoints, with the result that the four potentials across the condensers C1, C2, C3 and C4 across the secondaries of the transformers are all in quadrature and may be represented as $+e$, $-e$, $+je$, and $-je$. The rotor plates of the four condensers are connected together electrically so that the output current, i_5, is the sum of the currents through the four condensers. This output current produces a voltage across R5 which is amplified to make up for the loss through the phase-shifting network and to adjust the output voltage to equal that across the other terminating resistance R7. The amplified voltage is then applied to the vacuum-tube galvanometer. The voltage developed across the terminating resistance R7 of the other line is also applied through switch D1 directly to the vacuum-tube galvanometer, which will give a minimum reading when the phase of the voltage at input 1 is the same as that of input 2 and the two voltages are equal.

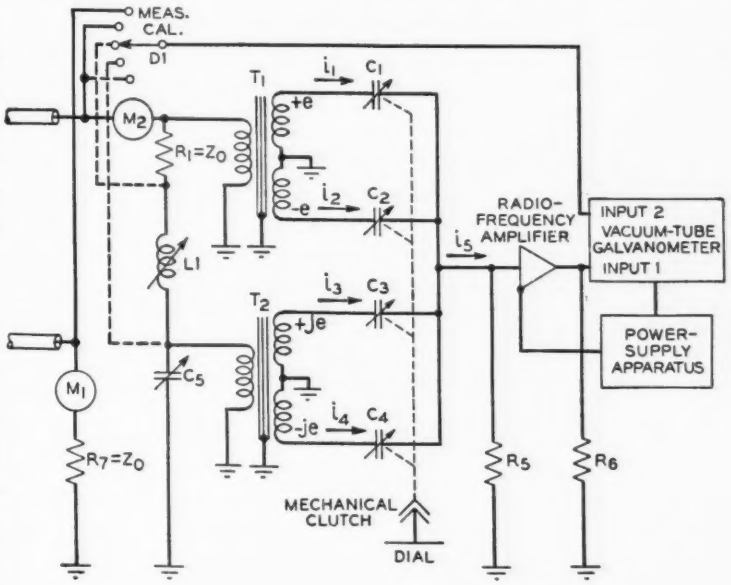


Fig. 4—Simplified schematic of the measuring circuit

If the rotors of the condensers were so positioned relative to the stators that the capacitances of the four condensers were always the same, the output current, i_5, would, of course, be zero, because four equal quadrature components sum up to zero. Actually, however, the stators and rotors of the four condensers are mounted as shown in Figure 5. There are four sets of stator plates but only two sets of rotor plates; one set of rotor plates

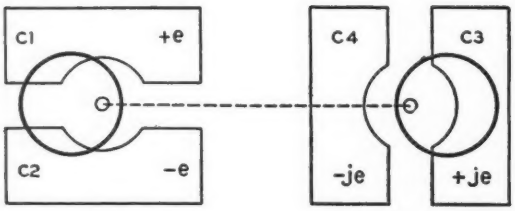


Fig. 5—Relative position of the stator and rotor plates of condensers C1, C2, C3 *and* C4

serving for C1 and C2, and the other for C3 and C4. The rotors are connected mechanically in the relative positions shown on the illustration, Figure 5, above, and are rotated together by a single dial.

In the position of the rotors indicated, the capacitances of C1 and C2 are alike and thus i_1 and i_2 flowing through the condensers are equal, but since they are of opposite phase, they cancel. The capacitance of C4, on the other hand, is zero and that of C3 is a maximum, so that i_4 is zero and i_3 is a maximum, and the resultant output, i_5, is equal to $+ji_3$, which applies a potential to the voltmeter proportional to $+je$. As the rotors are turned to the right, there is a progressive change in the magnitude of the four components, so that, after a 90-degree turn, i_2 is zero, i_1 is a maximum, and i_3 and i_4 are equal and opposite, so that the resultant current, i_5, becomes $+i$.

The values of the capacitances of the four condensers for various angular positions of the rotor are as indicated in the four graphs of Figure 6, and the component currents correspond to these capacitances. Since the currents flowing through C1 and C2 are always 180 degrees apart, they may be added algebraically to give the solid curve of Figure 7, which represents the real component of i_5. Likewise the currents flowing through condensers C3 and C4 may be added algebraically to give the dotted curve of Figure 7, which represents the imaginary component of i_5. The two components represented by these curves are the quadrature components of the resultant current and must be added vectorially to give i_5. The result of the vector addition is indicated for a number of angular positions of the rotor in Figure 8. It will be noted that for all angles of rotation of the plates, the magnitude of the resultant current, i_5, is the same and its phase angle is equal to the angle of rotation of the condenser rotors. Thus the voltage at the input of the voltmeter is always the same in magnitude but is shifted with respect to the

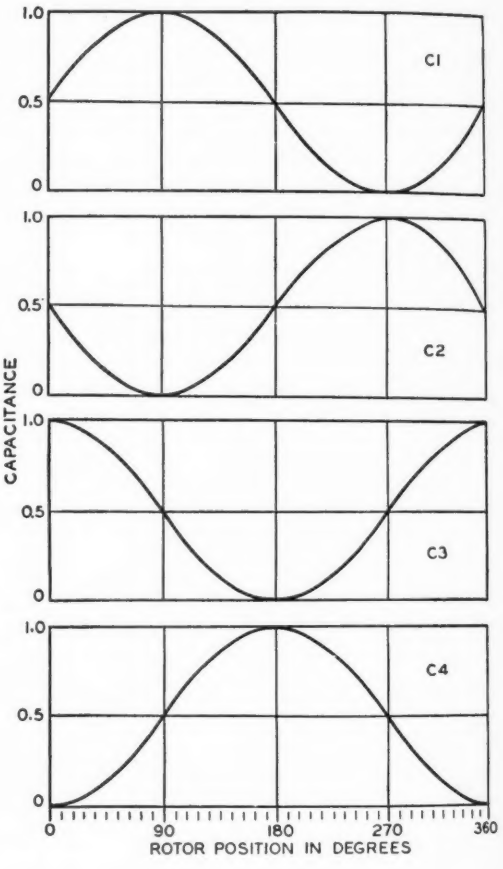


Fig. 6—Capacitance of the four phase-shifting condensers for various angular positions of the rotor

phase at the input to the phase-shifter by an amount equal to the rotation of the rotor plates.

The resistance and capacity network, R1 and C5, which provides the quadrature relationship required between the two transformers by the phase-measuring condensers, is adjusted by using the vacuum-tube galvanometer. Two contacts, in addition to the "CAL" and "MEAS" points, on the test switch D1 are provided as shown dotted in Figure 4 so that the voltage of condenser C5 to ground may be measured and the capacity adjusted until the voltage across it equals that of resistance R1 to ground. Another point on the switch enables inductance L1 to be adjusted so that its impedance is equal and opposite to that of condenser C5, as indicated by a minimum deflection upon the galvanometer. The proper adjustment of C5 and L1 may by this means be quickly established for any frequency and checked at any time without supplementary measuring equipment.

The vacuum-tube galvanometer, as already noted, gives a minimum reading when the potentials applied to its two inputs are in phase and equal in magnitude. Since one input is supplied directly from one of the transmission lines, and the other, from that of the other transmission line through the phase shifter, a minimum reading will be obtained when one input to the voltmeter has been shifted in phase sufficiently to bring it in phase with the other input, and the amount of phase shift necessary to bring this about is the original phase difference between the currents from the two transmission lines at the input to the measuring equipment.

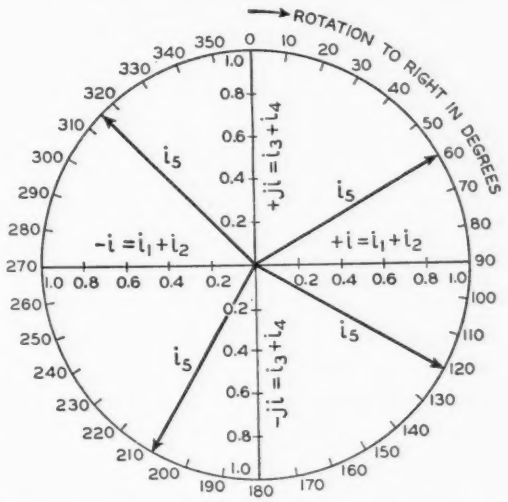


Fig. 8—Vector resultants of the curves of Figure 6 for various rotor positions

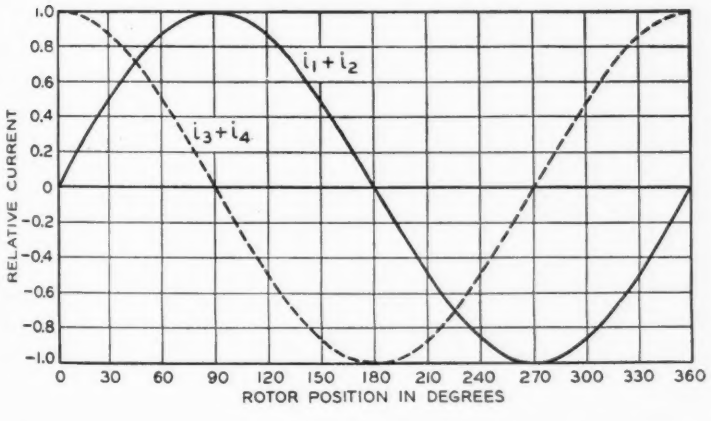


Fig. 7—Sum of i_1 *and* i_2, *solid curve, and of* i_3 *and* i_4, *dotted curve, for various angular positions of the rotor*

The relative magnitudes of the currents in the towers are determined directly from the readings of the radio-frequency thermal milliammeters M1 and M2. These meters are of the expanded-scale type having substantially linear scales from 50 to 250 milliamperes.

Terminations are provided for three sampling lines and a

selector switch has been provided which is wired to enable the relative magnitude and phase to be determined for each of three towers.

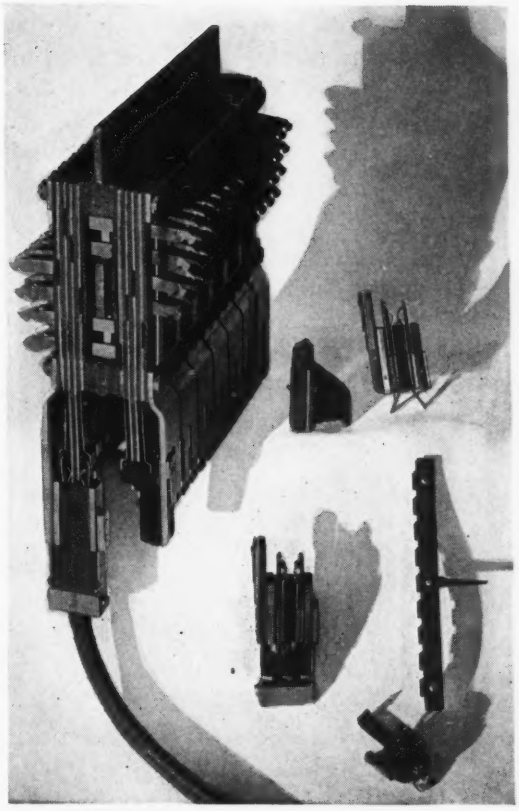
Another feature is a provision for interchanging the connections between the monitor proper and two of the sampling lines which makes it possible to re-measure an angle using an adjacent quadrant of the phase-measuring condensers, thus obtaining a substantial check upon the accuracy of the original adjustments and measurement. The same interchange provision makes it possible to eliminate meter errors that might occur from the relative magnitude determination.

This new monitoring equipment is useful not only in adjusting the pattern when the station is first put in operation, but in checking the performance of the array from time to time. As a permanent part of the equipment of stations using antenna arrays to secure controlled radiation, the apparatus makes it possible to check the performance of the array periodically, and thus to avoid a changing of the pattern caused by variations that are likely to occur.

Mrs. Gilbert Grosvenor, daughter of Alexander Graham Bell, and Mr. Grosvenor (at the right) hear Mrs. Anna Mae Swenson operate the Voder in Mr. S. S. A. Watkins' office at the Bell System Exhibit at the New York World's Fair

Jacks for Main Distributing Frames

By J. E. SHAFER
Electro-Mechanical Development



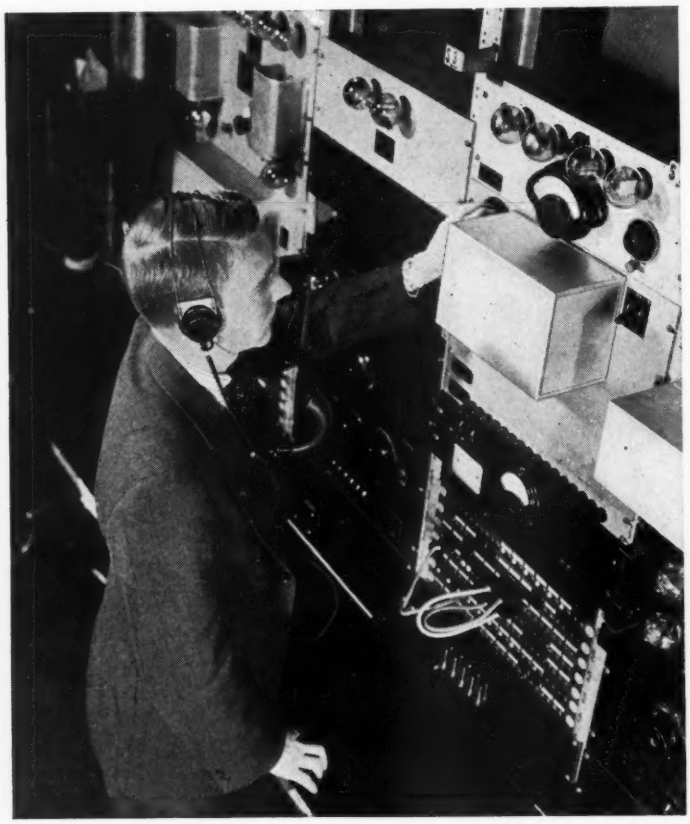
IN METROPOLITAN areas, where telephone circuits are installed in cables entirely underground, as many as thirty thousand pairs of wires may enter a single central office. These wires all terminate at the main distributing frame. To conserve space at this location a jack arrangement has been developed to connect the cable pairs to the central-office circuits. It replaces the protector mounting which is not needed where the outside plant is entirely underground, since excessive voltages cannot ordinarily be impressed on the circuits. Twice as many circuits can be accommodated in the same space by the use of this jack arrangement without sacrificing any of the testing arrangements now generally used.

A group of the new jacks is shown in the illustration. Each jack has two pairs of spring contacts which normally close the tip and ring of a cable pair to the tip and ring of the associated central-office circuit. Each set of springs is opposite another set on the other side of the jack and each set serves one cable pair. The incoming cable pairs are soldered to terminals on one side of the jack and the cross-connecting jumpers to the other side. The outside wires usually remain connected during the life of the office but the jumper wires are frequently changed. The terminals for both the outside wires and jumpers are mounted forward in an accessible position. Precious-metal contacts assure greater freedom from circuit noise than protector mountings which have base-metal contacts. A guide is also provided to hold the plugs in position and to insure their proper insertion into the jack.

New plugs and shields have been developed for the new jack. A test plug and a dummy plug are shown in place in the illustration. The test plug has four springs which are connected to the tip and ring conductors of the cable and to the jumper pair. By this plug the central office and cable circuits can both be patched to a testing station. Inserting the dummy plug disconnects the cable pair from the inside circuit; and this is equivalent to removing heat coils or dummy heat coils from a protector mounting.

Several other attachments are shown in the photograph, some with their protective covers removed. Above at the right is a test plug which has terminals from the two inner springs only and is used to check cable pairs during installation or in case of cable failure. Below at the left is a reversing plug which reverses the tip and ring connection to the line. A guard, shown near the bottom of the photograph, serves as a marker for important circuits to prevent accidental insertion of a plug. The object nearest the jacks is a shield to cover completely the front end of a jack when extra protection is desired. The gang plug at the right opens ten pairs at a time and is used principally in case of cable failure.

Substituting the new jacks for protector mountings will reduce appreciably the floor space required where protector blocks are not needed. In some cases it will make unnecessary a double-sided protector frame, the cabling that is necessary between the protector frame and the main frame, and the additional mezzanine platform and lighting facilities.



Testing toll circuits with a return-loss set which measures the unbalance between a line impedance and a network impedance. When the return-loss is high the balance is good and this condition makes two-wire repeatered circuits operate most satisfactorily

Contributors to this Issue

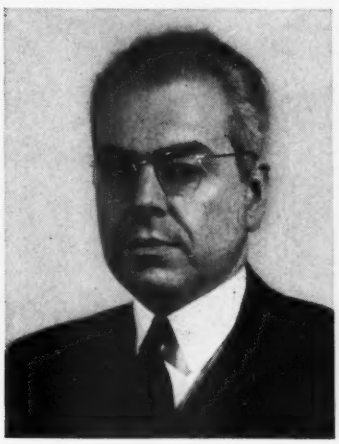
P. W. SWENSON graduated in 1927 from Worcester Polytechnic Institute with a B.S. degree in Electrical Engineering. He immediately entered the Systems Development Department of these Laboratories. After spending a year in the manual systems laboratory group, he transferred to the relay group where he has since been engaged in the application and development of relays for various central-office switching circuits.

J. W. DEHN joined the Engineering Department of the Western Electric Company in the fall of 1919, and at first engaged in laboratory testing and analysis of manual and panel telephone circuits. Subsequently he worked on the design of manual circuits and later of automatic testing circuits for panel offices. Since 1933 he has been engaged in the design of automatic testing circuits and marker circuits for the crossbar system. During this period, he has attended classes at the Polytechnic Institute of Brooklyn from which he received the degree of Electrical Engineer in 1932.

J. E. SHAFER joined the Laboratories immediately after receiving his B.S. degree in Physics at Pennsylvania State College in 1919. For eight years he was engaged in research testing of magnetic materials, after which he transferred to the Apparatus Development Department. Here he worked on the design of relays, switches to control electrolysis and message registers. He is now primarily interested in polarized relays.

J. F. MORRISON joined the Engineering Department of the Federal Telephone and Telegraph Company in 1923, where he engaged in the development and manufacture of the earlier broadcast receivers and transmitters. Previous to this time he had spent two years at the Electrical Vocational School, Buffalo, New York. In 1926 he left the Federal Company and joined the Long Lines Department of the American Telephone and Telegraph Company. The following year he was engaged as wireless operator by the Radio Corporation of America, and operated on Standard Oil Company ships between New York and South American ports. A year later he left to become Vice-President and Technical Director of the Buffalo Broadcasting Corporation which oper-

P. W. Swenson



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ated Radio Broadcast stations WKBW, WGR, WMAK and WKEN. In 1929 Mr. Morrison joined the Radio Development Department of these Laboratories. His work in that department has included the supervising of radio broadcast transmitter installations, radio transmission studies, and broadcast antenna design.

F. R. DICKINSON graduated from Union College in 1927 with the B.S. degree in Electrical Engineering. He at once joined the Technical Staff of the Laboratories, where with the Trial Installation Department he took part in various trials at a number of places scattered around the country. In 1932 he left the Laboratories and was engaged in the development of electrical instruments and public address equipment. Returning to the Laboratories in 1936, he joined the Toll Equipment Department, where he has since been engaged in studies of automatic regulation of carrier-telephone systems for open-wire lines.

R. L. TAYLOR received the B.S. degree in Chemical Engineering from the State College of Washington in 1928 and an M.A. degree in Chemistry from Columbia University in 1939. He joined the Laboratories in 1928. His work has been concerned mainly with measurements of the dielectric properties of organic insulating materials and studies of their stability to water and sunlight.